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ORIENTING RESPONSES IN A SELECTION OF COGNITIVE TASKS:
AN INVESTIGATION OF THE CONSTRUCT OF THE ORIENTATION REACTION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled ORIENTING RESPONSES IN A SELECTION OF COGNITIVE TASKS: AN INVESTIGATION OF THE CONSTRUCT OF THE ORIENTATION REACTION submitted by Richard M. Barham in partial fulfilment of the requirements for the degree of Doctor of Philosophy

ABSTRACT

The generality of phasic, tonic, and habituation aspects of the orientation reaction were investigated. Forty adults and 37 children were first given a selection of stimulus and task conditions as occasions for the elicitation of orienting responses. These responses were observed through simultaneous recording of galvanic skin and pupillary responses. Next, different stimuli were provided for the same subjects under a range of task conditions during which corneally reflected eye movements were recorded.

Electrodermal, pupillary, and eye-movement responses were separately submitted to factor analyses with independent solutions being computed and compared for adults and children. Further, a selection of measures from the three response classes were collectively factor analysed to investigate relationships among measures in different response classes.

The results failed to support the usual conceptualization of the orientation reaction as a fundamentally uniform reaction having distinct phasic, tonic, and habituation aspects. Specific response measures were imperfectly correlated with one another and were subject to patterns of association and dissociation as a function of such variables as task, age, and response mode. Accordingly, it was proposed that the orientation reaction is multidimensional in character. This conclusion is consistent with recent views on the possibly multidimensional nature of arousal.

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CHAPTER I

INTRODUCTION

This study was an investigation of relationships among selected components of the orientation reaction. The immediate concern was with the factorial structure of galvanic skin response, pupillary dilation and eye-movement measures to a number of auditory and visual stimuli. The aim was to investigate some of the generalities which hold both within and among specific response modes. In brief, the investigation probes the construct validity of individual susceptibility to the orientation reaction and its phasic, tonic and habituation aspects.

The theoretical frame of reference stems fundamentally from Soviet research and discussion concerning the orientation reaction. In general terms, this reaction comprises a set of responses which may include skeletal responses such as head and eye movements, together with a number of so-called vegetative responses such as changes in heart rate, and the galvanic skin response. This functionally related system of responses is believed to signal detection of a violation in expected stimulus input (broadly speaking, stimulus change,) and appears to prepare the organism for both better reception of stimulation and response to stimulation. It may occur either as an apparently unconditioned response, or as a conditioned response to so-called signal stimuli (such as a person's name or a warning cry). Repeated presentation of a stimulus complex is normally associated with habituation of the orientation reaction.

The wider and practical frame of reference, in terms of applied psychology, hinges on the seeming relationship between the orientation reaction and some aspects of attention. The functional characteristics of the reaction bear an obvious affinity with some attentional processes, considered at least in the lay sense, and a few writers (e.g., Zaporozhets, 1965) have been prepared to assume a considerable degree of identity between the two processes. Other writers have pointed to the conceptual confusion which surrounds the term attention (Berlyne, 1960; Mostofsky, 1970) and have cautioned against any glib equation of the orientation reaction and attention. Responsible interpretation of the functioning of the orientation reaction, however, does seem to allow a place for the construct in a description of some intensive and selective aspects of attention. If we accept this view, then the educational psychologist will be interested in the reaction for the light it might eventually shed on some of the many problems surrounding teaching and learning behaviors.

The orientation reaction is far from being a simple and well understood set of responses. Western interest in the reaction has burgeoned only in the last ten years and while Soviet interest has a more substantial history, potential information from this quarter has suffered in accessability, detail and differences in usage of technical terms. Nevertheless, from the observations of such Soviet writers as Luria (1963), Sokolov (1960, 1963) and Zaporozhets (1962, 1965) together with western accounts (Berlyne, 1960, 1963, 1970; Lynn, 1966; Reese and Lipsitt, 1970) much data and progress in interpretation have

been won.

Pavlov's early description of the reaction (1927) emphasized postural and specific skeletal responses which appear to involve observing and investigatory responses directed towards a source of stimulation. Included among these components of the orientation reaction are: a) momentary arrest of ongoing motor activity, b) turning of the head and eyes towards and about the source of stimulation, and c) other overt receptor adjustments such as turning (in some animals, pricking up) the ears towards the source of a sound stimulus.

More recently, and in concert with advances in instrumentation, interest has shifted towards more covert components of the orientation reaction. Included here would be: a) pupillary dilation, b) changes in electroencephalograph recordings represented by depression of the alpha rhythm, c) changes (commonly deceleration) in heart rate, d) vasoconstriction in limbs and vasodilation in head, e) a change in the galvanic skin response, f) momentary delay in respiration, and g) a general increase in muscle tonus. Many of these responses are now widely used to define changes in arousal.

Among the several problems associated with the orientation reaction which are still to be resolved is the fact that while the above responses define the reaction, not all of them are reliably present in all reactions. Indeed, research has long evidenced the modesty of correlation among physiological responses in general and among seeming indices of arousal in particular. In some respects, the uncertainty relating to the presence of the several components in a particular reaction may be held to weaken the theory of the orienta-

tion reaction. Even in the light of this problem, however, a tentative defence may be advanced in favor of the reaction.

First, with respect to the low correlations commonly found among physiological responses (Ax, 1953; Lacey & Lacey, 1958), it should be observed that few such studies have been reported which give deliberate account to the orientation reaction in designing occasions for making observations. In other words, many studies which intercorrelate a variety of physiological responses have failed to control for the occurrence of the orienting response itself (c.f. Taylor & Epstein, 1967). Since the physiology of the various components of the orientation reaction involves differences among the latencies of specific responses, it is all too easy to confound a response of interest with noise from unwanted orientations.

A second defence of orientation theory, despite low correlations among physiological responses, might be marshalled, or at least speculated, from another quarter. Some authors have drawn attention to the possible dimensionality of the arousal construct (Berlyne, 1967; Lacey, 1967). Very briefly, it has been suggested that there may be different kinds of arousal more or less as could be conceived by analogy with Thurstone's or Guilford's views on the structure of intelligence. Insofar as the orientation reaction is, at least in part, an arousal reaction, we could expect some dimensionality in orientation itself.

Consideration of the various components of the orientation reaction suggests a further problem. Conglomeration of the various components of the reaction within the one construct implies some unity

of process, perhaps both in origin and function, which might beg many questions. The most obvious of the possible disunities emerges from consideration of the skeletal components on one hand and the autonomic components on the other. The former, we could assume, might be more susceptible to voluntary control and the reinforcing contingencies of the environment than the latter.

Problems and questions of theoretical concern are inevitably related to practical issues. Accepting the claims that the orientation reaction is related to some aspects of attention, to qualitative factors influencing the reception of stimuli and to differentiation among subpopulations (e.g., Israel, 1966; Luria, 1963) then a variety of further questions emerge. Which among the components of the reaction are the more stable and accessible of measurement? Are there substantial redundancies among responses to a range of stimulus situations? Does the pattern of relationship among constituent responses change with age?

There are numerous such questions which could be raised. The point, however, is not to compile a catalogue of loose ends but rather to acknowledge the possible multivariate character of the reaction and to suggest the need to explore this very characteristic within a varied domain of eliciting stimulus situations. Most studies of the orientation reaction have examined single response components to a specific stimulus or category of stimuli. The investigation to be described was a limited approach to the multivariate analysis of the reaction.

CHAPTER II

REVIEW OF LITERATURE

Description of Recent Literature

An idea of the aspects of the orientation reaction which are capturing scientific interest can be gained by examining the range of publications on this topic from 1960 to 1970. It is clear from the number of publications which refer to his work that Sokolov has become a noted authority on the reaction. Many of the published studies and discussions devote themselves to analysis and testing of Sokolov's propositions. Taken together, the studies testify to the fact that the orientation reaction has the status of a construct embodying a considerable amount of presumptive theory. Details of the theory, however, do lend themselves readily to empirical investigation and the preponderance of research is designed towards this end.

Examination of more than 150 papers, books and abstracts concerned with the orientation reaction that have been published over the past ten years permits at least a cursory description of the various foci of interest in the reaction. Without claiming a meticulous rigor in classification, Table 1 provides a general description of the subject matter of these books and papers. Some publications, of course, embrace and have been represented in more than one category.

Investigation of the components of the orientation reaction (e.g., Uno & Grings, 1965) have been principally directed to heart

rate, galvanic skin response and the vasomotor response. Much less in evidence among the autonomic and sense organ changes are studies on respiration and pupillary dilation. A good number of studies have examined electroencephalographic desynchronization and there are also a few which investigate changes in the musculature, whether this be in the general skeletal system or in the skeletal muscles which direct the sense organs. Not evident in the table is the fact that comparatively few studies on the components of the orientation reaction have investigated more than one or two variables at a time, although the reaction itself comprises a constellation of responses.

Table 1

Categorization of Publications on the Orientation Reaction, Period: 1960-1970

Topic	Number of References
Anatomical and physiological	10
Components of	20
Conditioning of and function in conditioning	19
Conditions for elicitation	21
Covariates and associated state variables	12
Description of	21
Drug effects upon	4
Functions of	5
Habituation	22
Individual difference variables and sub-populations	19
Instrumentation	2
Ontogenesis and phylogenesis	11
Review	3

Of the publications concerned with either the conditioning of the orientation reaction or its role in conditioning, a preponderance of papers have appeared in Russian and many of these are not available in English translation. According to a number of these writers, the reaction appears to play a fundamental role in the formation of a conditioned response (Anokhin, 1965; Biriukov, 1965; Sokolov, 1963, 1965), first through its facilitation of perception, and second, perhaps, through the consequent increase in excitation which permits the formation of synaptic "connections".

There are numerous studies which examine the conditions necessary for elicitation of the orientation reaction. Much of the Soviet literature has been somewhat incautiously interpreted as suggesting that any form of stimulus change is a sufficient condition for elicitation. Unlike some of the other categories within Table 1, considerable western research interest has been expressed in this topic (Berlyne, 1958a, 1958b, 1961; Berlyne, Craw, Salapatek, & Lewis, 1963; Campos & Johnson, 1966; Zimny, Pawlick, & Saur, 1969). For example, in recent papers Bernstein (1969) and Graschenkov & Latash (1965) argue that a perceived stimulus change must first be evaluated as potentially significant before an orientation reaction will be given.

Descriptions of the reaction are now available from a number of sources. Principal among these would be books by Lynn (1966), Sokolov (1963) and a further book edited by Voronin, Leontiev, Luria Sokolov & Vinogradova (1965). More summary treatments are also available by Berlyne (1960) and Razran (1961).

Table 1 indicates that investigations concerned with the habituation of the reaction have been numerous. Habituation has been investigated not only to confirm the reliability or consistency of the process, but also to examine conditions which have a bearing upon rate of habituation. Some of these studies have specifically investigated and found some support for Sokolov's theory of the neuronal model. Stern (1968) has suggested relations between habituation and memory processing. Bernstein (1969) proposed that habituation is a two-stage process which first involves a match-mismatch process, but secondly involves evaluation of sensory data in relation to an expectancy.

Studies of individual differences have evidenced as one of their aims an attempt to distinguish between certain sub-populations (e.g., normal, mentally ill, retarded) with respect to orienting behavior (Kreindler, Krigel', & Poilich, 1963; Lebedinskaia, Feigenberg, & Freierov, 1962; Luria & Vinogradova, 1963; Maltzman & Raskin, 1965; Wolfensberger & O'Connor, 1967). Perhaps more than in most of the other categories in Table 1, studies of individual differences herald a tentative application of orientation theory to diagnosis, treatment and education.

In concluding discussion of the predominant categories in Table 1, some mention may be made of what is missing rather than present in the literature. The table itself, perhaps, reveals that phylogenetic and ontogenetic studies are not in abundance. This is understandable in terms of the costs and difficulties associated with developmental investigations. But the need for inquiries of this kind is nonetheless present since understanding and treatment of individual differences

is facilitated when psychologists can distinguish between the contribution of native and conditioned response mechanisms. It appears more than likely that there would be an interaction between the biology of the person on the one hand, and his profit from experience on the other (Biriukov, 1965; Kimmel, Pendergrass, & Kimmel, 1967; Zinchenko & Lomov, 1960).

An even more substantial lack in the literature has to do with the tonic phase of the orientation reaction. Although this aspect of the response is no doubt closely related to what western psychologists have investigated in terms of activation and arousal, little direct interest in either the tonic reaction or its relation to the phasic response has been manifest in the literature. Further, it could be added that there has been comparatively little interest expressed in reliability in the characteristics and occurrence of the reaction under different stimulus conditions, for the same subjects. In other words, there is little evidence to convince us that orienting responses, given for instance to meaningful verbal visual stimuli, have substantially the same characteristics as those responses given to meaningful nonverbal auditory stimuli.

Tonic and Phasic Reactions

Sokolov (1963, 1965, 1966) distinguishes two phases or aspects of the orientation reaction: phasic and tonic. The phasic form of the response is related to a "rapid activation of the analyzers in response to change in the environment" (Sokolov, 1965, p. 143). By comparison with the tonic form, it is brief in duration and rapid in

development. Most studies of the reaction investigate this aspect. The tonic reaction, by contrast, is slower in its development, persists for a longer period of time, and is not as clearly manifest externally. Quite clearly, however, the tonic aspect appears to be rather closely related to what western psychologists commonly refer to as activation or arousal.

Sokolov (1966, p.343), nevertheless, proposes that a distinction should be made between general activation and the tonic aspect of the orientation reaction. For instance, he distinguishes between the effect of stimulus intensity upon activation, and the supposedly non-specific intensification of arousal which is associated with some kinds of stimulus change. In Sokolov's own words: "...activation, as a component of the orienting reflex, must be distinguished from the activation reaction in general which implies all cases of intensification of the functional state" (Sokolov, 1966, p.343). He suggests further that the phasic and tonic reactions are not only intimately related, but that together they influence the rate of habituation (Sokolov, 1963, p.119). We might expect then that measures of the phasic and tonic reactions, and rate of habituation, would show some degree of relationship, perhaps through intercorrelation.

Apart from the reports of Sokolov, the writer is familiar with no studies which directly and experimentally investigate the tonic aspect of the orientation construct. Indeed, the literature must lead us to the view that a possible distinction between the tonic phase of the reaction and general activation is likely beyond our present opera-

tional capabilities. In the meantime we can pursue questions relating to the tonic reaction at least indirectly through more general studies of arousal.

One such study has addressed the problem by studying measures of autonomic arousal (Taylor & Epstein, 1967). These experimenters investigated covariation in heart rate and skin conductance in humans under varying stimulus conditions, and concluded that the study of arousal could most appropriately be undertaken, at present, through investigation of "the unique properties of physiological systems as they relate to the parameters of stimulus input" (Taylor & Epstein, 1967, p.524). Their investigation revealed no consistent relationship between heart rate and skin conductance responses; the relationships among the response measures appeared to depend upon specific characteristics of the stimulus situation. At the same time, these authors were unwilling to dismiss the potential usefulness of a general arousal variable, nor the possibility of ultimately operationalizing the construct.

Another interesting study which has a bearing upon the tonic phase of the orientation reaction, again indirectly, examined the effects of a verbally induced attentional set upon the electrodermal response (Korn & Moyer, 1968). These authors found that the brief instruction to "pay attention" was related to larger orienting responses to the first tone in each of two sets of twenty tones, and to more irregular habituation over the second set of tones.

A rather striking point not elaborated by the authors is that

following the supposed induction of the attentional set, and during an adaptation period, there were no statistically significant differences between experimental and control groups with respect to base conductance levels, change in conductance over time, or number of non-specific electrodermal responses. There was, however, a difference between groups in the magnitude of the phasic orienting response to the first presented tone, and a fall in conductance level for the experimental group during a rest period between the presentation of the two sets of tones.

It might have been expected that the attentional set would have induced a general arousal reaction, or perhaps tonic response, which would have been manifest in differentiated conductance levels between the groups during the adaptation period. According to orientation theory, this arousal response could then have been related to the group differences in magnitude of the phasic response. Such was not the case. Yet there was a predictable fall in conductance level for the "attention" group during a rest period. The authors themselves express difficulty in interpreting the rest period change in conductance. Taken on its own, this drop in conductance level does not seem unreasonable, but considered in conjunction with <u>common</u> group levels in base conductance <u>before</u> treatment, the problem becomes more real.

Among the broader interpretive integrations of studies on arousal and orientation are those of Berlyne (1963, 1964, 1967). Berlyne supports the notion that arousal might be a dimensional construct,

dependent in its functional forms upon stimulus and state variables as well as upon differences between physiological systems. Currently then, attempts to measure the supposed tonic response might fall flat, first because in its measurement, the response cannot readily be distinguished from other arousal responses; secondly, because different stimulus conditions might be expected to have differing effects upon the arousal response; and thirdly, because different physiological systems behave differently under varying stimulus conditions.

Habituation of the Orientation Reaction

Reference has already been made to the number of studies relating to habituation of the orientation reaction. Apart from inevitable interest in the process itself (Galbrecht, Dykman, Reese, & Suzuki, 1965), psychologists have shown particular interest in this phenomenon because of its importance in so-called inattentive behaviors (Mackworth & Otto, 1970). Numerous studies of habituation have been published since Lynn's (1966) summary of research and theoretical explanatory models. Some of these reports have implied considerable support for elements of Sokolov's theory (Houck & Mefferd, 1969; Zimny, Pawlick, & Saur, 1969); others have considered the effects of such stimulus conditions as set upon the course of habituation (Korn & Moyer, 1968); and still others have examined habituation of orienting responses in young children in the course of establishing and violating expectancies (Lewis & Goldberg, 1969). The greater number of studies of habituation have involved one or more physiological responses such as vasomotor (Stern, 1968), electrodermal (Zimny & Schwabe,

1965) and heart rate (Raskin, Hattle, Harris, & DeYoung, 1968) responses. With the exception of some systematic work issuing from a very few centers, there has been comparatively little investigation of habituation of skeletal orienting responses. The work of Kagan & Lewis (1965) and Lewis & Goldberg (1969), represents such an exception.

One of the more interesting of the studies of the skeletal response comes from the Stanford laboratories. Using the eye tracks of children aged two to seven, Mackworth and Otto (1970) appear to have presented clear evidence of habituation of the visual orienting response. The authors drew the conclusions from their study that children as young as two years evidence a tendency to habituate the visual orienting response, that age differences within the given stimulus conditions were slight, and that the rate of habituation appeared to be slower than is the case where simpler stimuli such as tones are used. The authors argue strongly in favor of the view that "selective attention and visual orienting are not merely happening together". They conclude that:

> ...because orienting responses are such an integral part of the attentive process and not merely an adjunct, a far more intensive analysis of visual orienting activity could lead to a great deal of much needed data on the course and nature of selective attention.
>
> (Mackworth & Otto, 1970, p.176)

A similar habituation effect among measures of eye-movement responses was observed by Torbit (1970) with older children, the effect being stronger for retardates than for normals. It would be worth knowing, now, whether or not habituation of skeletal components

of the orientation reaction is closely related to habituation of autonomic and other components of the reaction.

Age Differences

It seems clear that orienting responses occur under two distinguishable conditions. In the first place they occur as seemingly unconditioned responses consequent upon violation of an expectancy. Past experience, or learning, is assumed to influence the elicitation of such orienting responses only in the sense that the expectancies themselves are a function of experience. Secondly, an orienting response may occur as a conditioned response to certain stimuli or signals. Bearing these points in mind, we could postulate certain age differences with respect to: a) the specific stimuli which might be expected to elicit an orientation reaction, and b) differences in rate of habituation of the reaction to given stimuli. Considering, further, the biological bases of the reaction, it might be expected that orienting responses manifest in the first few months of life might differ from those of older people. The difference might involve reliability (regularity) in elicitation of the orientation reaction, differences in the functioning of the component responses, and possibly, differences in the magnitude of phasic and tonic responses.

Interest in the ontogenesis of the orientation reaction is evidenced principally in Soviet writings. Russian publications report differences with respect to age among animals (e.g., pigs, puppies, monkeys) in the emergence of various components of the reaction, in the stability of the reaction, and in rate of habituation to repeated

stimulation (Nikitina & Novikova, 1965; Volochov, 1966). Similar developmental differences have been found among human neonates compared with older infants and between prematurely born and normal term babies (Bronstein, Itina, Kamenetskaia & Sytova, 1965; Polikanina & Probatova, 1965). Among these studies somatic responses were commonly accepted as evidence of the presence of an orientation reaction, though physiological components were incorporated in some investigations.

With older children and adults, more experimental interest has been directed to individual difference variables and their possible relationship to orienting behavior (Luria & Vinogradova, 1963) than to possible developmental changes in the structure and functioning of the reaction. Accepting the biologically based age-related differences in the functioning of the reaction which have been reasonably confirmed for the very young child, Sokolov's theory would otherwise lead us to assume substantially similar response characteristics of the reaction among normal subjects to the same stimulus conditions. This author is aware of no attempt to directly verify this assumption.

Factor Analytic Studies

Among the applications of factor analytic techniques is the identification of traits or determinants which underlie sets of intercorrelated measures. Accordingly, they have much to offer as a method, in the early stages of inquiry into a construct where fundamental relationships among components of the construct are not clearly understood or confirmed. Yet this analytic tool has rarely been used in investigation of the orientation reaction. The few studies which are reported

relate primarily to investigation of Pavlov's propositions regarding the basic properties of the nervous system and have been conducted by Teplov and his colleagues.

One such factor analytic study reported by Teplov and Nebylitsin (1966) analysed the matrix of intercorrelations for parameters including: duration of alpha blocking to first presentation of sound and light stimuli; speed of extinction of orienting response to sound; mean duration of alpha blocking with conditioned stimulus. In all, seven variables were involved. Without reporting the results of the analysis in numerical form, the authors state that the several measures loaded on <u>one</u> factor, identified as representing higher nervous activity. The authors report a table of correlations all of which are positive and most of which are significant beyond the .05 level.

Another Soviet factor analytic study (Rozhdestvenskaia, Nebylitsyn, Borisova, & Ermolaeva-Tomina, 1963) used 21 different measures upon 40 subjects aged 18 to 35 years. Most of the measures stem directly from methods developed to test aspects of Pavlov's typology theory, and they included four orienting response measures concerning both magnitude and trials to habituation of the vasomotor response to auditory and visual stimuli. These four measures loaded on the second factor which was interpreted as representing balanced nervous processes. The interesting point in terms of the orientation construct is that the phasic and habituation measures were closely associated and relatively independent of other measures of nervous system functioning.

Further correlational studies are reported by Lynn (1966) and in these, as in the investigations summarized above, there was substantial intercorrelation of phasic and habituation measures of the orientation reaction. Sokolov's proposition, then, that phasic and habituation aspects of the reaction are interrelated finds a measure of support.

General Statement of the Problem

The current study will employ the methods of factor analysis to further the investigation of relationships among components of the orientation reaction. Repeated galvanic skin response, pupillary response and eye-movement response measures, taken as responses to: a) a selected variety of auditory and visual stimuli, and b) signal and non-signal stimuli, will be submitted to factor analytic treatments. The pattern matrices for responses in each of the three response categories will be separately examined for evidence of factors representing the phasic, tonic and habituation phases of the orienting response. In addition, comparisons will be made between factors extracted from separate analyses for adults and children. Finally, selected responses from the three response modes will be factor analysed as a set, with a view to examining possible relationships in orienting behavior <u>among</u> the three response modes.

CHAPTER III

RATIONALE AND HYPOTHESES

Rationale

There are many hypotheses, predicted relationships and embryonic laws concerning the orientation reaction. Together these constitute an interlocking system of predicted and supposed relationships which define the orientation reaction construct. Support for the construct is already well advanced, for almost any investigation of the reaction which has been conducted may be viewed as having contributed to the pool of data from which inferences regarding the validity of the construct may be drawn. In this as in other cases of construct validation, there is a dynamic relationship between accumulating research evidence and the substance or design of the construct itself. As findings inconsistent with the construct are accumulated, there are consequent modifications to relevant elements of the construct. As support for other elements are amassed, so too does the validity of the construct become more assured.

Construct validation is inevitably a gradual affair which can only be undertaken by the several efforts of investigators probing many aspects of a construct from many angles. Understandably then, and despite the accumulated research, we are yet a considerable distance from outright validation of the construct of orientation.

This fact, however unremarkable in itself, nevertheless presents a handicap to the applied psychologist who might wish to utilize the construct in his own field. There must be caution, if not unwillingness, in application of a theory to problems in human behavior when aspects of a theory are still somewhat assumptive. With respect to the orientation reaction, the work of psychologists and others has inevitably, and rightly, led to the association of the reaction with further hunches and guarded propositions. Many writers have proposed a relation between the orientation reaction and some aspects of attention; others have noted parallels with reinforcement (Maltzman & Raskin, 1965) and with drive (Berlyne, 1963). But all this being so, it would be improper to deceive ourselves into thinking that there were not still fundamental questions to be raised about the reaction.

Some of the many remaining questions have been suggested in the first two chapters. The first of these has to do with the properties of the orientation reaction in relation to the nature of the eliciting stimuli. It is quite evident from the literature that under conditions of a disconfirmed expectancy, many kinds of stimuli (verbal, nonverbal, visual, auditory) may elicit a specific orienting response. It is also clear that such responses may, for most people, be conditioned to certain signalling or alerting stimuli (Look out!). What is not so clear is whether or not the responses elicited under <u>differing</u> stimulus conditions are essentially the same response. The appearing similarity among these responses is insufficient justifi-

cation for their acceptance as being equivalent.

The second question concerns the relationship among phasic, tonic and habituation phases of the reaction. Sokolov (1963) has suggested that the phasic and tonic responses are interrelated and that together they influence the rate of habituation. We must ask whether or not tonic and phasic responses are indeed distinguishable, yet to some degree related. Are they associated with habituation rate, and if so, is the association of the same degree for, say, the galvanic skin response as it is for the pupillary response?

A third question was raised in the earlier chapters. What kind of equivalence is there between an orienting response observed as, for instance, a galvanic skin response and another observed as pupillary dilation or eye movements? This problem is of much the same nature as that concerning the effects of different stimuli. It is further complicated, however, by the fact that different physiological systems are involved. The point becomes more pressing where we wish to assume some kind of equivalence between somatic and skeletal response systems. We have noted that Berlyne (1967) and Taylor & Epstein (1967) are among those who postulate a dimensionality in the arousal system. If such dimensionality could be tentatively confirmed, new elements would need to be added, perhaps, to the orientation construct.

The fourth and final problem concerns the structure and characteristics of orienting behavior at different ages. Granted

that abundant evidence reveals that ten-year-old normals and some forty-year-old schizophrenics give orienting responses, we yet must question the degree to which the characteristics of the responses are the same. The literature review identified studies which confirm differences in response among certain sub-populations. Possible age differences, except in the case of the new-born, have not been widely examined.

Eysenck (1950), Guilford (1948) and Cronbach and Meehl (1955) are among those who, either directly or indirectly, have proposed the significance of factor analytic methods in contributing to the establishment of construct validity. In their classic paper on construct validity Cronbach and Meehl specifically identify factor analysis as one among a number of fruitful validation procedures. As Cattell (1966) points out, factor analytic methods are distinct from other procedures such as multiple correlation in "not arbitrarily choosing a criterion variable." Rather, factor analysis permits us to arrive "at a reduced number of abstract variables and a weighting of observed variables according to structural indications in the data itself" (Cattell, 1966, p.174). In taking a number of response measures to a variety of stimuli, as was the case in the study to be described, and seeking a "reduced number of abstract variables" which might be representative of the orientation reaction, factor analysis appears to present a potential means for further investigating the validity of the construct of the orientation reaction.

Purposes of the Study

The investigation to be described aimed to contribute to the analysis of the construct validity of the orientation reaction. The issues to be examined are fundamental to the general characteristics of the response and are of limited range. The purposes of the study can be described in terms of four phases or studies.

Galvanic Skin Response Study. The first study concerned measures of the galvanic skin response. It aimed to identify the factor structure of a number of galvanic skin response measures, including phasic response measures (amplitude), conductance change, rate of habituation, latency and recruitment. These measures were made of responses elicited by a number of visual and auditory stimuli including pure tones and anagram problems. A further goal was to compare the factorial structure for two independent groups, one comprising normal children, the other comprising adult students.

Pupillary Response Study. The second study again used factor analytic methods, this time in analysis of pupillary response measures and using the same stimuli and samples as in the study of galvanic skin responses. Pupillary responses were recorded concurrently with galvanic skin responses and included phasic response measures, mean dilation change over time, trials to an habituation criterion and latencies.

Eye-Movement Study. The third study applied factor analysis to eye-movement measures on the same two samples of subjects as in

studies one and two, but using a variety of different visual stimuli only. Response measures included number of refixations, length of eye-track between successive fixations, informational search score and number of unscored movie frames.

Combined Analysis. The fourth study used selected measures from the previous three studies and submitted them to a factor analysis with a view to determining the factorial structure of representative measures drawn from the three different response modes.

In all four studies the purposes involved interpretation of factors in terms of orientation theory with respect to possible:

1) similarity among responses, in any one response mode, to different stimuli;
2) identification of distinct phases of the orientation reaction;
3) confirmation of the above observations by comparison of factorial structure between the two groups of subjects;
4) identification of possible age differences in factor structure;
5) relationships among galvanic skin, pupillary and eye-movement responses.

Definitions

General Terms

Orientation reaction. A system of sympathetic, skeletal and other changes, essentially involving the whole body, which constitute a reliable reaction to the stimulus condition of disconfirmed expectancy (stimulus change). The reaction occurs relatively independently of the direction (i.e., increase or decrease) of stimulus change and habituates under continuing or regularly repeated presentation of a stimulus.

Component of the orientation reaction. Any one of the sympathetic, skeletal or sense organ changes (e.g., heart rate deceleration, eye movement, galvanic skin response) which is a regular constituent of the constellation of responses which comprise the orientation reaction.

Orienting response. A response in one of the components of the orientation reaction.

Phasic response. A rapid change in a component of the orientation reaction which returns within a few seconds to the original level, and which is a response to some change in the environment.

Tonic response. A comparatively slower change in a component of the orientation reaction, which persists longer than the phasic response and which is a response to some change in the environment. It is to be distinguished from other autonomic, skeletal and sensory changes indicative of arousal which are dependent upon, or specific with respect to, the direction of change in stimulus intensity.

Habituation. Decline in amplitude of the orientation reaction as a function of repeated or continuous presentation of the same stimulus. The decline may continue to the point where no reaction occurs at all.

Arousal. A generic term representing a continuous variable which is indicative of the state of an organism's psycho-physiological activity. Such activity may range from deep sleep at one end of the continuum to extreme excitement at the other.

Galvanic Skin Response Measures

Amplitude. Maximum change in (natural) logarithm conductance, within the one to three second period immediately following stimulus onset, recorded between the sites of electrode placement.

Conductance change. Difference between mean logarithm (natural) conductance observed at half-second intervals within two

distinct three second periods. In the study, the measures were taken for the three second period immediately preceding stimulus onset and for the three second period immediately preceding problem termination.

Latency. Period of time in tenths of a second from stimulus onset to response amplitude.

Recruitment. Period of time in tenths of a second from response onset to response amplitude, where response onset is represented on the chart record as a sharp decrease in resistance, and occurs within the one to three second period immediately following stimulus onset.

Rate of habituation. Measured as both number of trials, and period of time in seconds, from stimulus onset to the third consecutive no-response trial.

Pupillary Response Measures

Baseline. Mean level, as represented on the pupillary chart paper, of pupillary dilation observed at half-second intervals over the three second period immediately preceding stimulus onset.

Maximum dilation. Point of maximum pupillary response on the chart paper within a two second period immediately following stimulus onset.

Amplitude. Difference in arbitrary chart units between baseline and maximum dilation.

Base change. Difference between (natural) logarithm of number of chart units represented by baseline and (natural) logarithm of number of chart units represented by the pupillary response observed at half-second intervals within some other three second period. In the study, the mean pupillary response measures were computed within the three second period immediately preceding problem termination.

Latency. Period of time in tenths of a second from stimulus onset to response amplitude, where the maximum latency permitted is two seconds.

Rate of habituation. Measured as both number of trials, and period of time in seconds, from stimulus onset to the third consecutive no-response trial.

Eye-Movement Measures

Fixation. In general, a subject's "look" at any point within the stimulus field which, as a function of the recording instruments used, may be discriminated from any successive "look" at a different point within the stimulus field. More specifically, one or more successive corneal reflections, recorded at the rate of ten frames per second, within a circular area of 11.4 mm. diameter on the stimulus field.

A fixation is defined as complete when the corneal reflection has shifted by a minimum of 5.7 mm.

Number of refixations. The number of successive fixations recorded within any given period following the first fixation. In the study, all eye-movement measures were taken over the three second period immediately following stimulus presentation.

Tracklength. The distance, measured in mm., between two successive fixations.

Information Search Score. The field for each stimulus figure is divided into a 7 x 7 matrix. Each cell of the matrix is independently rated on a six-point scale by a group of judges according to their assessment of the relative information content within that cell. Each cell then receives a weighting (cell weight) which is the mean judges' rating. The information search score is the sum of the cell weights, for a given stimulus, multiplied by the number of corneal reflections observed within the cell throughout any given period (c.f., Conklin, Muir, & Boersma, 1968; Mackworth & Bruner, 1970).

Unscored frame. A movie frame in which the corneal reflection is either not visible or outside the calibrated boundaries of the stimulus field. Principal occasions for an unscored

frame are: looking off the stimulus field, blinking, change in fixation during the one-tenth second exposure of the frame.

Rationale for Response Measures

Extensive account of the rationale for the selection of response measures is not contemplated, but there is some point in making brief comment. There is continuing debate concerning the most appropriate measures for many of the physiological responses. Concerning the galvanic skin response, common practice is somewhat supported by research evidence (Darrow, 1964, 1967; Haggard, 1949; Martin, 1964; Montagu & Coles, 1966) in favoring a measure of amplitude (change in logarithm conductance) as an appropriate measure. Notwithstanding common practice, Wolfensberger and O'Connor (1967) have reported that recruitment measures are more responsive to stimulus and subject differences than amplitude or latency measures. On the other hand, Surwillo has argued on the basis of his own data that galvanic skin response latency might prove to be a useful "measure of level of attention independent of differences in motivation" (Surwillo, 1967, p.227). In view of these various propositions, it seems appropriate to include amplitude, latency and recruitment measures as data for factor analysis.

Similar doubt surrounds the choice of the "best" measure of the dilation response. Particularly in comparison to use of the galvanic skin response, the pupillary response has been rarely used in studies of the orientation reaction. Recent pupillary studies

have emphasised cognitive processing variables such as processing load (Kahneman, Beatty, & Pollack, 1967) and cognitive load (Bradshaw, 1968). It seems doubtful to this writer that such interpretations are altogether compelling alternatives to others which might incorporate phasic and tonic aspects of the orientation reaction, or perhaps more general elements of arousal theory (Boersma, Wilton, Barham, & Muir, 1970). Accordingly, and since there are some fundamental physiological relationships between the galvanic skin response and pupillary responses, the pupillary measures have been designed to closely parallel the skin response measures. Both amplitude and latency measures are used in the pupillary study, but the recruitment measure was not adopted since dilation responses appear to be made at a comparatively rapid and uniform rate.

There is no well-established precedent for the choice of dependent measures in the eye-movement study. In the immediate post-Pavlovian stage of inquiry into the orientation reaction, overt body movements such as turning the head and eyes in the direction of stimulation, were taken as indicative of an orientation reaction. Much the same is true of more recent studies of orienting behavior in the infant (Kagan & Lewis, 1965). This consideration, nevertheless, does not rule out the possibility that somewhat more molecular aspects of the behavior of the eye do not themselves have some functional relationships with the orientation reaction.

Given an interest in investigating the more molecular eye-movement responses, the choice of measures must be influenced by the

criteria of apparent meaningfulness in the current research context, and the demonstrated usefulness of defined measures from other related studies. Both of these criteria have been applied in the current study. Of the four measures defined, tracklength and number of refixations (of which duration of fixation is a function) gain some credence from two reports. In a vigilance study, Mackworth, Kaplan, & Metlay (1964) demonstrated that subjects manifesting the greater frequency of eye movements detected more signal stimuli. Observing (investigatory) responses in this visual task situation appeared to play a role in the efficiency of attentional behavior. In the second study, Krugman (1968) found a relationship between scanning ("spread-out" looking) and learning, which suggested that some instrumental observing responses are better than others where visual perception is involved in a discrimination learning task.

Two further eye-movement measures which logically appear to be meaningful in relation to attending behavior are the information search score and unscored frame variables. The first of these measures appears to reflect some aspects of selectivity in looking behavior whereas the second, unscored frames, may be assumed to reflect, in some degree, distractability in looking responses. The four measures then, tracklength, refixations, information search score, and unscored frames have been employed in the eye-movement study.

Lastly, in considering the eye-movement measures in relation to the skin response and pupillary measures, it should be

added that there is no overwhelming basis for assuming that visual observing responses will be simply or directly associated with physiological components of the orientation reaction. Such may be argued notwithstanding the general claim that eye movements constitute a component of the reaction. Soviet writings, in fact, commonly suggest that a relatively quiescent (intake) phase of the orientation reaction is followed normally by a more active phase of investigation. It is conceivable that the physiological components of the reaction are principally related to the quiescent phase whereas the eye movements are related to the investigatory phase, in which case there might be little association between response measures taken from the different response domains. In the study to be described, however, eye movements were recorded within the same period of time following stimulus onset as were the galvanic skin response and pupillary response components of the orientation reaction. In this sense, a somewhat fundamental provision was made for a relationship between eye movements and the physiological components of the orientation reaction to be revealed by the data, if such a relationship does exist.

Hypotheses

Since the study is fundamentally investigatory in conception, and since there are no comparable investigations reported, there is no solid basis for deriving hypotheses concerning all of the dependent measures used. Some of the measures indeed, such as recruitment

and unscored frames, were utilized in a somewhat speculative manner in order to observe what the analyses revealed. This comment is particularly applicable to the eye-movement study in which it is one of the writer's concerns to discover whether or not measures being used in the local laboratory (Boersma, Muir, Wilton, & Barham, 1969a, 1969b; Torbit, 1970) were related, in terms of the orientation construct, to other physiological variables.

Galvanic Skin Response Study

Hypothesis 1: A minimum of three factors will emerge, these being tentatively interpretable as phasic, tonic and habituation factors, none of them being a general factor. It is further assumed that for both separate analyses, that is for children and for adults, the factor pattern will appear similar.

Hypothesis 1.1: A minimum of three galvanic skin response factors will emerge:

(i) phasic--amplitude measures derived from all five stimulus conditions, and including responses to both auditory and visual stimuli;

(ii) tonic--conductance change measures derived from the two anagram tasks, and including responses to both auditory and visual stimuli;

(iii) habituation--the two interdependent measures of rate of habituation of the galvanic skin response.

Hypothesis 1.2: The same three factors will emerge in identifiable form for both groups, adults and children.

Pupillary Response Study

Hypothesis 2: A minimum of three pupillary factors will emerge, these being tentatively interpretable as phasic, tonic and habituation factors, none of them being a general factor. It is further assumed that for both separate analyses, that is for children and for adults, the factor pattern will appear similar.

Hypothesis 2.1: A minimum of three pupillary response factors will emerge:

(i) phasic--amplitude measures derived from all five stimulus conditions, and including responses to both auditory and visual stimuli;

(ii) tonic--base change measures derived from the two anagram tasks, and including responses to both auditory and visual stimuli;

(iii) habituation--the two interdependent measures of rate of habituation of the pupillary response.

Hypothesis 2.2: The same three factors will emerge in identifiable form for both groups, adults and children.

Eye-Movement Study

No hypotheses are advanced for the eye-movement study. The factor analysis is undertaken on an exploratory basis to permit examination of the factors which do emerge. Factors will be described and interpreted in terms of the internal evidence permitted by the study. Further interpretation of the factors in relation to the orientation reaction will be made in the light of the combined analysis in which selected eye-movement measures are factor analysed along with selected galvanic skin response and pupillary response measures.

Combined Analysis

Hypothesis 3: It is hypothesized that a minimum of three factors will emerge, these being tentatively interpretable as phasic, tonic and habituation factors, none of them being a general factor. It is further assumed that for both separate analyses, that is for adults and for children, the factor pattern will appear similar.

Hypothesis 3.1: A minimum of three factors will emerge:

(i) phasic--galvanic skin response and pupillary amplitude measures, and perhaps, one category (i.e., tracklength, or refixation etc.) of the eye-movement measures;

(ii) tonic--galvanic skin response conductance change and pupillary base change measures, and perhaps,

one category of the eye-movement measures;

(iii) habituation--rate of habituation measures from the galvanic skin response and pupillary studies, and perhaps, eye-movement response measures from the prolonged search task.

Hypothesis 3.2: The same three factors will emerge in identifiable form for both groups, adults and children.

CHAPTER IV

METHOD

Subjects

Normal school children and senior undergraduate university students comprised the two groups which participated in the investigation. The children were volunteers from two city elementary schools. Children whose school records suggested evidence of sensory, emotional or organic anomalies or medically diagnosed skin conditions were excluded from the volunteers. The records of four subjects were not included in the final sample due to incomplete data and failure in the operation of the apparatus. The final sample included 37 children having a mean chronological age of 11.3 years (SD = 0.6 years) and a mean intelligence quotient of 119 (SD = 9.8) as reported in school records. Twenty-one subjects were males.

Forty-four student volunteers from a senior undergraduate course in Educational Psychology comprised the second group. Students sustaining any defects in vision or hearing, or medically diagnosed skin condition were not accepted. The records of four adult subjects were excluded from the final sample, three because of incomplete records and one because of a failure in operation of the polygraph. The final sample included 40 subjects having a mean chronological age of 23.7 years (SD = 4.1 years). Nineteen subjects were males. In neither the adult nor the children's group were volunteers accepted

who had corrected defects in vision or hearing.

Apparatus

A Grass model 5 polygraph incorporating a 5E DC driver-amplifier and 5P1 low-level DC pre-amplifier was used for recording galvanic skin responses. Zinc electrodes were used in accordance with the methods of Lykken (1959). The active electrode comprised a one-quarter inch solid zinc cylinder inserted in a lucite housing. The inactive electrode comprised a three-quarter inch diameter zinc cylinder fitted below the flange on a lucite housing so as to form a shallow cup suitable for receiving the electrolyte. The active electrode was applied to the central whirl on the distal phalange of the left thumb using Lykken's (1959) procedure for corn pad attachment. The inactive electrode was attached to a lightly sanded area of the skin on the volar surface of the left forearm at a distance of approximately two inches from the wrist. The electrolyte was zinc sulphate within a cornstarch base according to Edelberg and Burch (1962). Adequacy of preparation was checked by measurement of resistance at the inactive site in accordance with the simpler of the two methods suggested by Montagu and Coles (1966).

A Polymetric pupillograph recorder, Model V-1165, was used to obtain pupillary records. The instrument comprises three main parts: an image transducer (optical lens element and video tube), a signal analyzer, and a Hewlett-Packard Model 681 strip chart recorder. The lens projects an image of the subject's pupil onto the surface of a

video tube. Pupil images are recorded at the rate of 60 times per minute and are transformed into sequential signals which are analysed to yield further signals whose magnitude is directly proportional to pupil diameter. An ink record of the magnitude of the electrical signals is obtained from a continuous strip of chart paper.

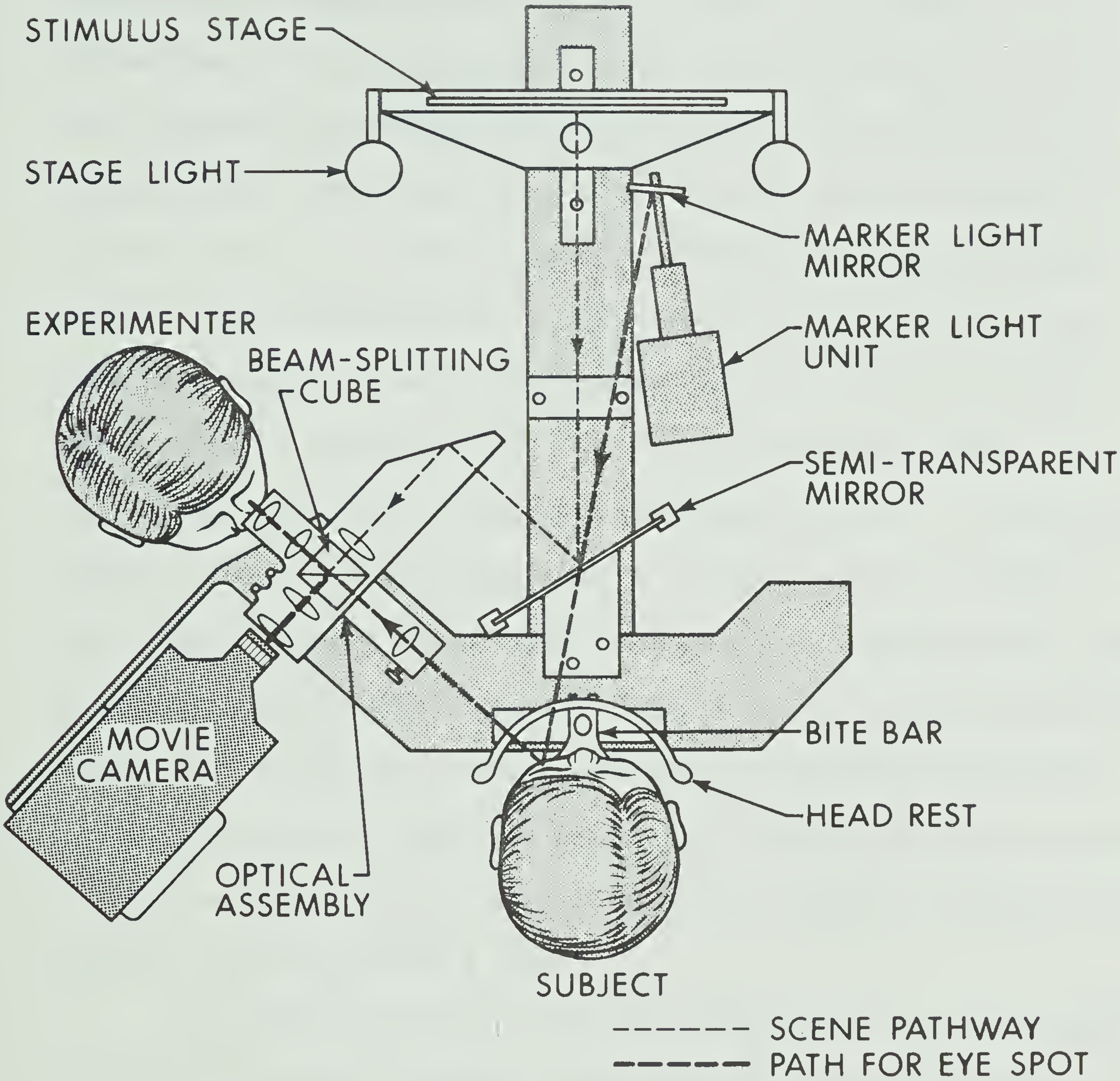
A Pathe "Professional" 16mm reflex movie camera, with a constant exposure rate of ten frames per second was used to record eye-movements. The camera is one element of a Polymetric Products Eye-Movement Recorder, (Movel V-1164-1), which utilizes the principal of corneal reflection of a spot of light superimposed upon the photographed image of the stimulus material (cf. Mackworth, 1967). See Figure 1 for a schematic representation of the apparatus.

Task instructions and auditory stimuli were supplied through a binaural headset associated with a Sony tape recorder (Model TC-777-4J) and integrated amplifier (Model 1120). White noise was fed through the amplifier circuit from a Marietta generator (Model 24-21B).

Ampex magnetic tape was used for pre-recording instructions and auditory stimuli. The audio signals were supplied by a Heathkit Audio Generator, Model IG 72, the interval between signals being controlled by a bank of Hunter timers.

All auditory signals were fed through a voice key to activate event recorders on the polygraph and pupillograph. Where visual stimuli were presented, event recorders were manually activated.

Eye-movement records were scored by means of an X-Y Plotter which converted coordinates of fixation points to voltage readings.



SCHEMATIC VIEW OF EYE MOVEMENT CAMERA

Figure 1

Rationale for Selection of Stimulus Materials

A fundamental concern in the selection of stimulus materials was that a variety of stimulus conditions would be provided for the observation of responses, thereby presenting an opportunity to note similarities or differences in the orienting response when elicited under different conditions. For the galvanic skin response and pupillary studies, the adoption of this principle led to the selection of both auditory and visual stimuli, and both non-signal and signal stimuli. More specifically, in tasks one, two, three and six, pure tones were used as stimuli, thus making these four tasks comparable with respect to the physical qualities of the stimulus itself. In task one the tones were presented as non-signal stimuli. In task two identical tones were presented over an extended number of trials to permit habituation of the orienting response. In task three the pitch of the tones was altered to permit dishabituation of the orienting response, and in task six, tones qualitatively comparable with those used in task one were presented again, but this time as signal stimuli. On this last task, subjects were instructed to *think* of pressing a button every time they heard a tone.

Still with reference to the skin response and pupillary studies, two further stimulus conditions were chosen to permit comparison of responses made to auditory and visual stimuli which were qualitatively comparable, except with respect to the mode of sensory stimulation. For tasks four and five then, anagram problems were presented, each problem being preceded by the signal stimulus "Ready!". Amplitude

measures were taken on the response given to the "Ready" signal whereas conductance change and base change measures were taken on the response given to the anagram problem itself. These anagram tasks provided better for the measurement of the longer term tonic or arousal reactions than did the presentation of consecutive single tones.

The same rationale with respect to variety of stimulus conditions applied in the selection of stimuli for the eye-movement study. Tasks one, two and five all employed Sam Slick pictures selected from the same source and randomly assigned to tasks. In task one the stimuli were presented as a non-directed search task, that is, without instructions to respond to the stimuli in any particular way. Task two was a prolonged search task which provided for a longer stimulus viewing period than task one. Task five was a directed search task in which subjects were instructed to respond to the stimuli in a particular manner. Two further tasks, three and four, were comparable to tasks one and five respectively in terms of the instructional conditions, but they differed in stimulus content.

Since the measurement of physiological and eye-movement measures is both time consuming and costly, a further consideration underlying the selection of stimuli and stimulus conditions was provision for analysis of the data by factorial designs at a later stage.

Stimulus Materials and Conditions

Galvanic Skin Response and Pupillary Response Studies

Stimulus materials were identical and responses were simul-

taneously recorded in the galvanic skin response and pupillary studies. Throughout the presentation of stimuli, white noise at the level of 62db was presented through the headset, with stimuli superimposed above the level of white noise. Six stimulus conditions were provided, with repeated measures being taken under each condition. See Table 2 for a summary of the six stimulus conditions. The stimulus conditions (tasks) were as follows:

(i) Tasks one, two and three were presented sequentially, without pause or interruption between tasks, with instructions given only before commencement of the first task. These instructions asked the subject to sit still and to look within the viewing area on the viewing stage in front of him. No indication was given of the nature of the stimuli to follow. These, and instructions for other tasks, are given in Appendix A.

In this first task, five successive pure tones at 72db, and at a frequency of 700 cps were presented. Intervals between tones had a mean length of 20 seconds within a range of 12 to 28 seconds. These intervals were chosen to provide ample time for recovery of responses and were of sufficient length and irregularity to minimize habituation.

(ii) The second task represented an habituation condition. Forty further tones, at the same loudness and pitch as those in the first task, were successively presented at

Table 2

Summary of Stimulus Conditions Used in the Galvanic Skin Response and Pupillary Studies

Task Number	Stimulus condition	Stimulus description	Number of stimuli	Response specified by instructions	Order of presentation
1	non-signal	700cps tone	5	none	1st
2	non-signal	700cps tone	40	none	2nd
3	non-signal	1000cps tone	2	none	3rd
4	signal	auditory: "Ready" & anagrams	4	solution	randomly alternated 4th or 5th
5	signal	visual: "Ready" & anagrams	4	solution	randomly alternated 4th or 5th
6	signal	700cps tone	5	imagined button press	6th

regular intervals of five seconds. Rate of habituation measures, for both galvanic skin response and pupillary responses, were calculated from the first-presented tone in the first task to three consecutive no-response trials. Since varying intervals separated the first five tones in the first task, rate of habituation was measured as both number of trials and latency in seconds to criterion. Forty-five tones is more than is normally required to produce habituation of the orientation reaction. This greater number was selected both to provide for any exceptional cases and to permit comparison with a sample of retarded children to be incorporated into the investigation at a later stage.

(iii) Two further tones of 72 db but of frequency 1000 cps were presented. The goal here was to provide for dishabituation of the orientation reaction and to permit incorporation into the study of response measures observed under this different condition.

(iv) Four anagram problems (see Appendix B) were presented aurally from magnetic tape. Galvanic skin response and pupillary records were taken continuously for ten seconds prior to the presentation of the first stimulus until the conclusion of the task. Following ten seconds of white noise alone, the word "Ready" was presented, followed in two seconds by consecutively presented letters comprising

the anagram. Each letter of the anagram (three letters for children, four for adults) was presented at an interval of approximately 1-1/2 seconds. Problem solution was terminated, if the problem was not already solved, 30 seconds following the provision of the last letter.

Amplitude measures were made of the response to the "Ready" signal. Conductance change and base change measures relative to the three second period immediately preceding the "Ready" signal were taken to the response to the anagram problem itself.

(v) Four visual anagrams (see Appendix B) were presented on the viewing stage of the eye-movement apparatus. Instructions, which included provision for a visual example, were provided over the headset. As with task four, galvanic skin response and pupillary records were taken continuously throughout the task. A ten second period preceded the presentation of stimuli. During this period white noise was supplied over the headset and a blank card was on the viewing stage. Following the ten second period, a card having the printed word "Ready" was dropped onto the stage. Approximately two seconds later, a card with the scrambled letters of the anagram was presented in the viewing area. Problem solution was terminated at the expiry of 30 seconds as in task four.

The letters of the anagrams, three eighths of an inch

in height, were inscribed in Indian ink on a white background. The width of the elements of the letters was one thirty-second of an inch. To assure control of differences in light intensity which could influence the dilation response (Woodmansee, 1966) the stimulus cards had been scanned after preparation by a Photo Research Corporation Spectra Brightness Spotmeter. This examination revealed that differences in light intensity on and between letters was less than the minimal differences in light intensity across the card as a whole.

(vi) Five pure tones were presented, at the same loudness and frequency as in the first task. Intervals between tones again had a mean of 20 seconds and were randomly chosen from within the range 12 to 28 seconds. On this task, subjects were instructed to <u>think</u> of pressing a button which lay under their right forefinger, each time they heard the tone (signal stimulus). They were asked, however, not to depress the button.

<u>Eye-Movement Study</u>

Representations of all stimuli used in the eye-movement study are given in Appendix B.

Five stimulus conditions or tasks were presented (see Table 3). Throughout all tasks, white noise at 62 db was provided over the headset to mask noises which might initiate unintended orientation reactions. Prerecorded instructions were presented from magnetic tape before each

Table 3

Summary of Stimulus Conditions Used in the Eye-Movement Study

Task Number	Stimulus condition	Stimulus description	Number of stimuli	Response specified by instructions	Order of presentation
1	non-directed search	*Sam Slick* pictures	3	none	randomly alternated 1st or 2nd
2	prolonged search	*Sam Slick* pictures	3	none	follows task 1
3	non-directed search	pairs of line drawings	3	none	randomly alternated 1st or 3rd
4	directed search	WAIS incomplete pictures	3	find missing part	randomly alternated 4th or 5th
5	directed search	*Sam Slick* pictures	3	recall picture content	randomly alternated 4th or 5th

task. Two tasks provided stimulus materials for which no instructions were given beyond the general suggestion that subjects might look at the stimuli (see Appendix A). These two tasks are referred to as non-directed search tasks. A third task provided for a longer period of visual examination of the stimuli than in the tasks just described, again without instructions to examine the figures in any particular way. This task will be referred to as a prolonged search task. Two further tasks provided for visual examination of stimuli, but this time with specific instructions to engage in a certain kind of cognitive activity with respect to the stimulus. These two tasks will be referred to as directed search tasks. Tracklength, number of refixations, information search score and number of unscored frames were the dependent measures. The information search score, however, was not used in task three. The tasks were as follows.

(i) For the first non-directed search task, three early 19th century Sam Slick (Haliburton, 1956) picture characterizations representing old-fashioned human dress and situations were presented. Each picture had considerable information content and was chosen because of the comparative novelty of the scene. Eye movements were filmed during calibration of the camera and for the five second presentation of each stimulus card. Only the first three seconds of stimulus viewing were used in the analysis.

(ii) Task two followed task one without pause or the pro-

vision of further directions. In this prolonged search task the viewing period analysed in the study was the 55th to 57th second of continuous viewing. The last presented stimulus figure from task one became the first stimulus for task two. Two further stimulus figures from the same Sam Slick collection were added to provide three stimuli in all. Eye movements were filmed during the first five seconds and last five seconds of continuous viewing over a one minute period.

(iii) As a further non-directed search task, three pairs of line drawings were provided. On the left side of each stimulus display was a regular, symmetric and simple looking figure within a viewing area of 2-1/4 square inches. On the right side of the display was an irregular, asymmetric figure, comprising the same elements as the other member of the pair, but with the elements scrambled to make a more complex looking figure. The members of each pair of figures were separated by a minimum of 2-1/4 inches. Eye movements were continuously filmed during calibration of the camera and for a ten second period following stimulus presentation. In this as in the two following tasks, only the first three seconds of stimulus viewing were used in the analysis.

(iv) In the first directed search task a set of three stimuli was used, these being incomplete pictures (boat, sun and

woodpile) selected from the Incomplete Picture subtest of the <u>Wechsler Adult Intelligence Scale</u> (Wechsler, 1959). Subjects were permitted to view the pictures until they had arrived at their solution or until 30 seconds had elapsed, whichever came first. Subjects were asked to report their solution.

(v) The second <u>directed</u> search task consisted of a further set of three <u>Sam Slick</u> pictures. The instructions required subjects to recall and report as many elements or items from the pictures as possible upon termination of stimulus presentation. Stimuli were presented for five seconds.

Procedure

The experiment was conducted in a sound attenuated laboratory with preparation facilities and variable light control. Subjects in the sample of children were transported to the university by taxi. A male experimenter had a female assistant throughout the procedure. The voice of the assistant had been used on tape for the recording of task instructions.

When they entered the laboratory, all subjects were given a general description of the apparatus and permitted to ask questions about the equipment. No specific indication of the nature of the study was given. Following three or four minutes of such discussion, the subject was seated on an adjustable chair while the experimenter described the attachment of galvanic skin response electrodes. At

the same time, the assistant prepared the site of electrode placement, made the attachment, and checked on the resistance to assure that preparation had been adequate. A bite-bar for use during the presentation of all stimuli was fitted in place and the subject made an impression with his teeth on the initially soft dental compound covering the bar. The headrest, seat and bite-bar were adjusted to a position of comfort. Subjects then had the headset adjusted and were provided with white noise while the TV camera associated with the pupillary equipment was directed at the eye and the necessary adjustments made. In all, a minimum of ten minutes elapsed between attachment of the galvanic skin response electrodes and the presentation of the first task.

During the presentation of all tasks, subjects were widely enclosed by a black draw-curtain to minimize the number of distractable stimuli. The experimenter and his assistant were outside this enclosure. A constant low level of visible light was used in the laboratory from five minutes before the beginning of the experiment until conclusion of the entire experiment to control for pupillary adaptation.

Stimuli associated with the combined galvanic skin response and pupillary studies were presented in their entirety first. Tasks one, two and three were presented to all subjects in the same consecutive order and took a period of nine minutes, including the giving of instructions. These tasks were followed by a rest period, normally of two or three minutes, but depending upon the reported comfort of

each subject. Children were offered two or three candies ("Smarties") during this period.

Tasks four and five, visually and auditorily presented anagrams, were presented in random alternation, with the four problems within each task also having random order of assignment. Each of these tasks lasted approximately five minutes including the giving of instructions. Variations in the period of the task depended upon each subject's solution time. Subjects came off the bite bar following each specific problem to report the solution.

The sixth and final task, using a tone as a signal stimulus, in the combined galvanic skin response and pupillary studies was always presented last in the series and took just over three minutes. Throughout this task, the subject's hand was observed to determine whether or not, despite instructions, the button was depressed in response to the tone. Since only four such observations were made, this fact was ignored in analysis of the data. A rest period of two or three minutes followed and children were again offered one or two candies. Subjects were asked about their comfort in the apparatus, and in three cases, a glass of water was offered. The eye-movement study followed.

Prior to the filming of eye movements, the eye-movement camera was adjusted and calibrated. White noise was again presented over the headset throughout the presentation of stimuli. All tasks were preceded by taperecorded instructions. The camera was recalibrated before the presentation of each stimulus.

Tasks one and two were presented successively without pause, task two always following task one. Task one, however, was presented either first or second in the series for any particular subject, in random alternation with task three. Tasks four and five always followed the presentation of the first three tasks, but themselves were presented in random alternation. In both tasks four and five, subjects came off the bite bar, following the presentation of each stimulus, to give their response. The order of stimulus presentation within tasks was randomized, with the exception that the last stimulus presented in task one was always the first stimulus used for task two.

The eye-movement study took approximately 15 minutes to complete, depending upon time taken for camera calibration in individual cases, rest periods and the period taken for solution of the problems in the picture completion task, task five. Subjects spent approximately one hour in the laboratory. Children were offered the remainder of a small box of Smarties to take with them from the laboratory.

Scoring Procedure

All data from the galvanic skin response and pupillary studies were manually scored in terms of the definitions previously listed. All response measures were transferred to punched cards and converted to mean response measures for each specific task. These mean response measures were the subject of analysis.

Within the galvanic skin response study, the following measures were used.

(i) Five mean amplitude measures, one for each task

excluding the habituation task.

(ii) Five mean latency measures, each associated with a mean amplitude.

(iii) Five mean recruitment measures, each associated with a mean amplitude.

(iv) Two habituation measures derived from the habituation task.

(v) Two mean conductance change measures, one derived from each of the anagram tasks.

A total of 19 response measures for each subject was submitted for analysis.

Within the pupillary study, the following measures were used.

(i) Five mean amplitude measures, one for each task excluding the habituation task.

(ii) Five mean latency measures, each associated with a mean amplitude.

(iii) Two habituation measures derived from the habituation task.

(iv) Two mean base change measures, one derived from each of the anagram tasks.

A total of 14 response measures for each subject was submitted for analysis.

In those cases where physiological responses were not given to all stimuli, means were calculated for the actual number of responses given rather than on the basis of all possible responses. In

the main, such reduced numbers of observations contributed to mean amplitude measures taken in task one for the galvanic skin response. In this task, habituation onset sometimes occurred before presentation of the fifth stimulus. In the pupillary study, such no-response observations occurred with more frequency and irregularity.

Various methods have been suggested for the treatment of physiological artifacts, and a number of these have been summarized in a recent paper (Sternbach, Alexander, Rice & Greenfield, 1969). Surprisingly with the children, there was no coughing or sneezing and only five (movement) artifacts occurred in the total sample of galvanic skin response data. These artifacts were handled by exclusion. The situation was not as happy with the pupillary data. Almost all subjects had some occasional artifact among their pupillary records and it was considered too costly to handle these artifacts by exclusion. Blinking, occasional electrical interference and eye movements appeared to occasion most artifactual pupillary records. The eye movements seemingly altered reflectance of light from the pupil and produced brief irregularities within the record. Since handscoring was being used, subjective estimations (Sternbach et. al. 1969) were used to deal with these artifacts.

Each movie film frame of the eye-movement record was scored on the X-Y Plotter by representing the coordinates of each fixation point on punched cards. A computer program derived the four eye-movement measures from this data. Within the eye-movement study, the following measures were used.

(i) Five mean tracklength measures, one for each task.

(ii) Five mean number of refixation measures, one for each task.

(iii) Four mean information search scores, one for each task excepting task three.

(iv) Five mean number of unscored frames, one for each task.

A total of 19 response measures for each subject was submitted for analysis.

To provide the information search score value for each of the 49 cells comprising each stimulus picture, ten graduate students in educational psychology acted as judges. (Instructions to judges are reported in Appendix C.) Each cell of each stimulus figure was rated on a six-point scale and the mean of the judges' ratings for each cell computed. The unadjusted reliabilities of ratings over all stimulus figures gave Spearman-Brown reliabilities ranging from 0.94 to 0.97. The information search score values were input to the computer and a program used to compute each subject's score.

Statistical Analysis

Galvanic Skin Response Study

The two groups, children and adults, were separately analysed according to the same procedures. A principal components analysis was carried out and the principal axes orthogonally transformed according to the varimax criterion. Communalities for the various response measures were abstracted from this solution.

Following a decision regarding the number of factors to be extracted, the unrotated factors were subjected to oblique transformation. The technique employed followed Hakstian's (1970) generalization of the Harris-Kaiser (1964) method. In the general formulation, a primary-factor pattern matrix, $\underline{P}$, is seen as being obtainable by

$$(1) \qquad \underline{P} = \underline{Q}\,\underline{M}^{p}\,\underline{T}\,\underline{D},$$

where $\underline{Q}$ (n x m) is the matrix of unit-length latent vectors and $\underline{M}$ (m x m), the diagonal matrix of latent roots (with the exponent $\underline{p}$) of an estimated $\underline{R} - \underline{U}^2$, $\underline{T}$ (m x m) is an orthogonal transformation matrix, $\underline{D}$ (m x n) is a diagonal rescaling matrix and $\underline{n}$ and $\underline{m}$ are the number of variables and factors respectively. Further, $\underline{T}$ may be obtained by maximizing any specialization of the general "orthomax" criterion

$$(2) \qquad n \sum_{j=1}^{n} \sum_{p=1}^{m} b_{jp}^{4} - \underline{w} \sum_{p=1}^{m} \left(\sum_{j=1}^{n} b_{jp}^{2} \right)^{2} = \text{maximum}$$

where $\underline{b}_{jp}$ is the loading of variable $\underline{j}$ on orthogonally transformed factor $\underline{p}$, and $\underline{w}$ may vary from 0 (quartimax) through 1 (varimax) and $\underline{m}/2$ (equimax), to $\underline{m}$ or beyond. In general, the larger the value of $\underline{w}$, the more equal the variance contribution of the factors. In the galvanic skin response and other studies to be reported, many values of $\underline{p}$ in (1) and $\underline{w}$ in (2) were tested in the search for least factorial complexity.

The solutions so obtained were described and interpreted. Since there had been but little support in the literature for the use of latency and recruitment measures, and since these measures did

not tend to load on factors along with amplitude and the other measures of principal interest, the whole procedure was repeated with the latency and recruitment measures excluded.

The decision to utilize an oblique solution, where this provided less factorial complexity than an orthogonal solution, was guided not only by the search for simple structure, but also by Sokolov's proposition that phasic, tonic and habituation aspects of the orientation reaction are functionally related. It was supposed that an oblique solution might provide a better basis for the demonstration of such a relationship than an orthogonal solution.

In the galvanic skin response study, as in the remaining studies, transformation of the factor matrix for one group to provide maximum overlap with the matrix for the other group was tried. Such a transformation would permit the closest comparison between groups along with confirmation of the solution through replication. It was found, however, that such a transformation either brought about no improvement in comparability of the pattern matrix between groups, or as was more commonly the case, seriously disturbed the level of simple structure which had been attained. Accordingly, these transformations are not recorded in the results. Instead, since the variance contribution of the factors was typically a little higher for children than for adults, factors have been reported and described for both adults and children in terms of the order of emergence of factors for <u>children</u>.

Pupillary Study

The procedure used in the galvanic skin response study was followed in the pupillary study.

Eye-Movement Study

The procedure used in the galvanic skin response study was again used in this study. Since there had been no basis in the literature for suspecting that any one combination of eye-movement measures might be more meaningful than any other set, there was no analysis in the eye-movement study with a reduced number of variables as was the case for the skin response and pupillary studies.

Combined Galvanic Skin Response, Pupillary and Eye-Movement Study

Since the number of dependent measures from all three previous studies in relation to the number of subjects was too great to permit factor analysis of all the measures, a selection of measures from the three studies had to be made for analysis in the combined study. The selection was made on the basis of the magnitude of the loading of specific measures on the factors which appeared to best represent aspects of the orientation reaction. That is, measures with high loadings on the factors of interest were selected for submission to the combined analysis. The actual selection of specific measures, then, could only be made in the light of the results of the three previous studies.

CHAPTER V

GALVANIC SKIN RESPONSE STUDY--RESULTS AND DISCUSSION

Summary of Design

Galvanic skin responses were recorded during the presentation of six tasks, with each task involving the presentation of successive stimuli. The dependent measures used in the analysis were arithmetic means, calculated for responses to all stimuli within a particular task, for amplitude, conductance change, latency and recruitment. On one of the six tasks, rate of habituation only was computed, this being measured both as number of trials, and period of time to the habituation criterion.

Task one presented five tones as non-signal stimuli with varying intervals between each tone. Response measures taken to task one were amplitude, latency and recruitment.

Task two was an habituation task for which only the two rate of habituation measures were taken. The stimuli from task one were included as the first five stimuli and were followed by forty further tones, all of the same pitch and intensity, but with equal time intervals between successive tones following the fifth tone.

Task three consisted of the presentation of two further tones having an assumed discriminable difference in pitch from the preceding tones. The purpose of this task was to provide for the taking of response measures of the dishabituated orientation reaction. As in

task one, the response measures were amplitude, latency and recruitment.

In task four there was auditory presentation of four anagram problems, each preceded by the auditorily presented signal stimulus "Ready". A maximum of thirty seconds was permitted for problem solution. Amplitude, latency and recruitment measures were made of the response to the ready signal. Conductance change was also computed for the mean level of conductance in a period preceding presentation of the problem compared with the mean conductance level preceding termination of the problem. Order of presentation of tasks four and five was randomly alternated to subjects.

Task five was comparable to the preceding task in all ways except that the stimuli, including the "Ready" signal preceding presentation of the anagrams, were visually presented.

Task six involved the presentation of five further pure tones, on this occasion as signal stimuli for the response of making an imagined button press response to each tone. The interval between successive tones was varied. Response measures calculated on this task were amplitude, latency and recruitment.

In all, nineteen response measures were taken, these being derived from performance on six tasks. There were two groups of subjects, adults and children, and the measures for each group were separately committed to statistical treatments which permitted the extraction and description of factors. Principally to investigate replicability, a comparison of factor composition between the two

groups was made.

Galvanic Skin Response Study--Nineteen Variables

Description of Analyses--Nineteen Variables

Principal component analyses were carried out on both the adult and children's groups with extraction, in the first instance, of all factors having eigenvalues equal to or greater than unity. Further component analyses were made with successive extraction of between three and nine factors and the several solutions examined for shifts in the variance contributions of the several factors. For the adult sample there were five eigenvalues of greater than one, but seven such values for children. In terms of the scree test applied to eigenvalues, it appeared that there might be four meaningful factors to be extracted for adults and five for children. Considering all the relevant evidence concerning the number of factors to be extracted, the best interpretation of factors appeared to be permitted by the extraction of five factors for each group.

Following the decision regarding the number of factors to be extracted, the unrotated factors were subjected to oblique transformation. The technique employed followed Hakstian's (1970) generalization of the Harris-Kaiser (1964) method. In the present study, many values of p and w were tested. Ultimately, the least factorial complexity was attained with (a) $p = 0.25$ and $w = 1.0$ for adults, and (b) $p = 0.5$ and $w = 1.0$ for children.

Means and standard deviations of dependent measures for the

two groups are reported in Table 4. With respect to amplitude and conductance change measures, which represent natural logarithmic transformations, it should be noted that low absolute values in Table 4 correspond to comparatively large changes in the galvanic skin response, and vice versa. It may also be noted in passing that of the nine measures concerned with amplitude, conductance change or habituation, the variance of seven of the measures is greater for children than for adults. Of the ten latency and recruitment measures on the contrary, there are only three measures for children which have higher variance than for adults. Whether or not these seeming differences are statistically significant, of course, is a further question.

Intercorrelations for the 19 variables, for adults and children respectively, are recorded in Tables 5 and 6. It is clear from these tables that intercorrelations are generally low, with higher values characterizing the data for children than for adults over the first nine variables.

Tables 7 and 8 give the oblique primary pattern matrices. Communalities reported in these tables were abstracted from preliminary varimax solutions. Correlations among the five oblique factors are recorded in Tables 9 and 10 for adults and children respectively. Eigenvalues for these and all further analyses reported in the current study are recorded in Appendix D.

Table 4

Means and Standard Deviations for Adults

and Children on Nineteen Galvanic Skin Response Variables

Measure	Adults		Children	
	Mean	S.D.	Mean	S.D.
1. Amplitude--five pure tones	-0.017	0.013	-0.015	0.038
2. Amplitude--dishabituation, two pure tones	-0.019	0.013	-0.027	0.020
3. Amplitude--four auditory anagrams	-0.022	0.018	-0.019	0.013
4. Amplitude--four visual anagrams	-0.023	0.010	-0.020	0.014
5. Amplitude--five pure tones, imagined button press	-0.017	0.010	-0.021	0.015
6. Conductance change--audit. anagrams	-0.009	0.037	-0.023	0.057
7. Conductance change--visual anagrams	-0.021	0.052	-0.009	0.019
8. Habituation--number of trials	11.625	8.910	13.081	12.904
9. Habituation--number of seconds	128.300	73.275	135.405	98.457
10. Latency--five pure tones	2.151	0.530	1.832	0.580
11. Recruitment--five pure tones	1.689	0.691	1.394	0.474
12. Latency--dishabituation, two pure tones	1.976	0.446	1.786	0.442
13. Recruitment--dishabituation, two pure tones	1.876	1.016	1.521	0.511
14. Latency--four auditory anagrams	2.040	0.438	1.865	0.314
15. Recruitment--four auditory anagrams	1.772	0.623	1.500	0.308
16. Latency--four visual anagrams	1.860	0.405	1.577	0.428
17. Recruitment--four visual anagrams	1.797	0.661	1.506	0.313
18. Latency--five pure tones, imagined button press	2.045	0.384	1.861	0.297
19. Recruitment--five pure tones, imagined button press	1.680	0.617	1.619	0.360

Table 5

Intercorrelations for Nineteen Galvanic Skin Response Variables for Adults (N=40)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	--																		
2	41	--																	
3	28	53	--																
4	22	31	64	--															
5	18	51	47	32	--														
6	15	24	28	26	20	--													
7	12	-15	05	20	06	02	--												
8	-12	-04	-02	-01	-09	05	22	--											
9	-12	-05	-03	-00	-10	05	24	99	--										
10	-03	-10	-23	-16	-02	-07	-14	14	15	--									
11	-14	24	20	22	38	08	-03	-11	-11	21	--								
12	-23	30	12	-10	33	-11	-12	-16	-18	24	45	--							
13	03	03	08	-04	09	02	-05	-14	-13	42	59	49	--						
14	-04	09	18	03	20	15	-02	-08	-08	31	56	54	87	--					
15	08	12	-21	-01	-02	29	04	07	07	29	54	30	60	57	--				
16	-17	08	-05	-09	09	13	-11	-01	-01	39	48	60	68	76	58	--			
17	-10	29	25	-01	10	13	-20	-08	-09	31	68	60	83	73	55	68	--		
18	-17	06	-04	-04	24	02	-02	-06	-06	38	57	55	71	71	52	78	67	--	
19	12	19	04	-00	-15	26	-15	-04	-05	25	47	33	78	73	73	68	81	62	--

*Decimals have been omitted.

Table 6

Intercorrelations for Nineteen Galvanic Skin Response Variables for Children (N=37)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	--																		
2	58	--																	
3	71	51	--																
4	66	58	82	--															
5	83	56	56	71	--														
6	16	-06	06	-07	07	--													
7	24	07	25	31	29	42	--												
8	23	05	-01	09	13	-09	-16	--											
9	25	04	-01	10	12	-09	-15	98	--										
10	-70	-32	-50	-35	-68	02	-25	-11	-11	--									
11	-29	-17	09	02	-09	00	-03	-01	-00	26	--								
12	04	-04	16	07	-02	12	22	-33	-32	17	34	--							
13	09	-29	10	07	04	17	38	-29	-29	-07	51	49	--						
14	17	08	38	20	22	17	16	-24	-24	05	61	69	43	--					
15	09	36	05	15	24	09	19	-05	-07	-05	57	-01	25	30	--				
16	17	12	-11	-02	12	15	24	-26	-26	05	18	43	23	41	27	--			
17	08	11	26	-02	01	05	-03	-28	-29	-16	27	41	56	40	40	22	--		
18	13	03	31	34	37	12	50	-33	-32	-10	42	42	50	60	36	19	23	--	
19	00	24	38	29	-05	-10	17	-23	-23	12	47	30	44	46	51	14	62	44	--

*Decimals have been omitted.

Table 7

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.25, $\underline{w}$ = 1.0) for Adults (N = 40)

Nineteen Galvanic Skin Response Variables*

Variable Factor	I	II	III	IV	V	h^2
1	-187	155	-157	-679	-041	556
2	-037	725	064	-275	-408	784
3	-024	812	-003	-162	070	743
4	003	581	-026	-231	406	634
5	110	824	-013	225	030	688
6	075	158	098	-607	036	455
7	130	008	137	031	865	762
8	-071	021	986	-014	013	979
9	-065	008	983	-012	039	983
10	394	-185	277	089	-291	390
11	725	312	-051	127	115	636
12	596	336	-050	445	-231	734
13	911	-080	-098	-077	025	836
14	898	054	-035	-037	083	802
15	738	-239	107	-379	064	723
16	847	-051	083	057	-099	759
17	820	127	001	-069	-201	829
18	871	033	016	189	041	761
19	781	-202	-008	-462	-118	903
Variance contribution	6.11	2.66	2.12	1.70	1.37	13.96

* Decimals have been omitted.

Table 8

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.5, $\underline{w}$ = 1.0) for Children (N = 37)

Nineteen Galvanic Skin Response Variables*

Variable Factor	I	II	III	IV	V	h^2
1	046	898	153	118	149	884
2	-197	718	-076	-324	-151	660
3	328	835	-072	045	-187	817
4	138	829	040	-084	-070	734
5	-052	845	089	-079	240	823
6	-001	-049	040	055	732	531
7	097	241	-083	002	728	665
8	-226	102	899	-135	-081	934
9	077	086	1003	093	-111	1052
10	125	-735	025	-117	-105	573
11	511	-288	221	-596	007	800
12	960	-059	188	271	071	894
13	646	-070	-134	-083	255	608
14	774	103	-028	-138	095	725
15	-048	069	025	-938	202	921
16	265	-038	-122	-117	398	320
17	529	090	-294	-242	-216	544
18	475	197	-180	-213	334	607
19	481	114	-222	-523	-260	750
Variance contribution	3.94	4.25	2.22	2.06	1.82	13.84

*Decimals have been omitted.

Table 9

Correlations Among the Five Oblique Factors for Adults

Nineteen Galvanic Skin Response Variables*

Factors	I	II	III	IV	V
I	---				
II	086	---			
III	-010	-081	---		
IV	-069	-182	-016	---	
V	-208	043	110	-051	---

*Decimals have been omitted.

Table 10

Correlations Among the Five Oblique Factors for Children

Nineteen Galvanic Skin Response Variables*

Factors	I	II	III	IV	V
I	---				
II	046	---			
III	-123	040	---		
IV	-230	-065	075	---	
V	144	079	-081	-022	---

*Decimals have been omitted.

Description and Discussion of Factors

The factors will be described in the order in which they emerged in the solution for children, and this principle will be followed throughout all studies to be described. The decision was made in favor of children since throughout most of the solutions to be described in this and the following studies, the analyses extracted a higher proportion of the total variance for children than for adults.

For each factor, loadings will be listed in order of decreasing magnitude. Since the smaller of the two samples comprised 37 subjects, in the galvanic skin response and all remaining studies factor loadings of .400 and higher will be reported and discussed. Loadings lower in value than .400, given the sample size just quoted, could not confidently be taken to represent more than chance contributions to factor composition.

Factor I--Latency and Recruitment

Adults

13.	Recruitment, task 3	.911
14.	Latency, task 4	.898
18.	Latency, task 6	.871
16.	Latency, task 5	.847
17.	Recruitment, task 5	.820
19.	Recruitment, task 6	.781
15.	Recruitment, task 4	.738
11	Recruitment, task 1	.725
12.	Latency, task 3	.596

Children

12.	Latency, task 3	.960
14.	Latency, task 4	.774
13.	Recruitment, task 3	.646
17.	Recruitment, task 5	.529
19.	Recruitment, task 6	.481
18.	Latency, task 6	.475

For both groups, Factor I is distinguished by loadings from the latency and recruitment measures. There is considerable comparability in the general pattern of loadings for both groups, but whereas for adults nine latency and recruitment measures are represented on Factor I, for children only six out of the possible ten such measures are involved.

For the purposes of the present study, the principal point of interest about Factor I is that latency and recruitment measures are loading separately from amplitude and conductance change measures.

In brief then, Factor I is a latency-recruitment factor, is a broader group factor for adults than for children, and is distinct from those factors having loadings from the variables of principal interest, namely amplitude, conductance change and habituation.

Factor II--Phasic Response

Adults		Children	
5. Amplitude, task 6	.824	1. Amplitude, task 1	.898
3. Amplitude, task 4	.812	5. Amplitude, task 6	.845
2. Amplitude, task 3	.725	3. Amplitude, task 4	.835
4. Amplitude, task 5	.581	4. Amplitude, task 5	.829
		10. Latency, task 1	-.735
		2. Amplitude, task 3	.718

Factor II is defined, principally, by the several high loadings of amplitude of the galvanic skin response. For adults, four of the possible five amplitude measures load on Factor II, and for children, all amplitude measures have high loadings on this factor.

For the children's group, variable 10, response latency on the first task, has a moderately high negative loading on Factor II. The comparatively strong contribution of variable 10 to this factor is puzzling, since there are not even moderate loadings of latency measures taken on responses to other tasks. A tentative, though nonetheless interesting, interpretation of the latency loading may, however, be advanced in terms of one of Surwillo's propositions.

Surwillo (1967) has presented data which he interprets as evidence that galvanic skin response latency might be functionally related to degrees of attentiveness. If it could be assumed that experimentally naive children, as compared with the more sophisticated adult university students, were most highly aroused (and attentive) during the first of the several tasks, then the contribution of variable 10 to Factor II for children only might be explicable in Surwillo's terms. That is to say, the children's assumed high attentiveness on the comparatively novel and ambiguous first task, influenced their latency of response and was thereby instrumental in bringing about an association between latency on task one and the more regular measures of arousal, namely amplitude.

Since Factor II is primarily defined by amplitude measures in both groups, interpretation of the factor must be guided by that fact. Amplitude measures are normally taken as indicative of the phasic aspect of the orienting response. It is significant for the current study that amplitude measures, irrespective of the task or cognitive conditions influencing the task, load together on the same factor.

Accordingly, it is tentatively proposed that Factor II confirms some generality for the notion that phasic responses, as measured by an electrodermal response, are comparable whether elicited by visual or auditory stimuli, and over a variety of stimulus conditions.

Factor III--Habituation

Adults		Children	
8. Habituation, # of trials	.986	9. Habituation, # of sec.	1.003
9. Habituation, # of sec.	.983	8. Habituation, # of trials	.899

For both groups, adults and children, Factor III is defined by the two related measures of rate of habituation, variables 8 and 9. The loadings are high in both groups and there are no further variables which load on this factor. Accordingly, the factor is described as an habituation factor. For the purposes of the present study, it is important not only to note the replication of factor composition from one group to the other, but also that this habituation factor is independent of contributions from the amplitude and conductance change measures.

Factor IV--Indeterminate

Adults		Children	
1. Amplitude, task 1	-.679	15. Recruitment, task 4	-.938
6. Conductance change, task 4	-.607	11. Recruitment, task 1	-.596
19. Recruitment, task 6	-.462	19. Recruitment, task 6	-.523
12. Latency, task 3	.445		

Factor IV is not readily interpretable, especially since it has a comparatively different composition for the adult and children's groups. As may be seen from inspection of Tables 7 and 8, two variables from the adult group and two from the children's group are complex variables which make at least moderate contribution to more than one factor. It may further be noted, by inspection of the loadings on Factor IV for both groups, that the direction of the contribution of the amplitude and recruitment measures is the same in each group, thus indicating some similarity between the nature of the factor for adults and children.

For adults, Factor IV is complex in its heterogeneity. It may be seen from inspection of the intercorrelations reported in Table 5 that (a) variables 1 and 6 correlate negligibly with each other; (b) they both have modest correlations with variable 12; and (c) that variables 12 and 19 have moderate intercorrelations. Furthermore, it can be seen in the same table that variable 1 actually has higher correlations with the remaining amplitude measures than it does with the latency and recruitment measures. Hence it appears that the contribution of variable 1 to Factor IV rather than to Factor II is explicable more in statistical than functional terms.

An additional point of interest about Factor IV for adults is the separation of the two conductance change measures from each other in their contribution to factors. Whereas variables 6 and 7 have a moderate correlation for children and load together on Factor

V, the same variables have negligible correlation in the adult sample and load on different factors. An explanation of these differences cannot be advanced in terms of the data and analyses on hand. The issue is worth further investigation, however, and might have less to do with age differences than it does with differences in difficulty of tasks.

For the group of children, Factor IV appears to have a more readily interpretable composition. It comprises three of the five recruitment measures and has no loadings from the visual task. For this group, the factor seems to represent recruitment of the galvanic skin response to auditory stimuli.

The composition of Factor IV raises more questions than it answers. If the factor could be replicated in a further study, then the differences between adults and children represented by the factor composition would be worth further inquiry. A descriptive label for this factor is not warranted by the interpretation which can currently be advanced.

Factor V--Tonic Response

Adults		Children	
7. Conductance change, task 5	.865	6. Conductance change, task 4	.732
2. Amplitude, task 3	-.408	7. Conductance change, task 5	.728
4. Amplitude, task 5	.406		

One again, this factor is more simply defined for children than for adults. For both groups, the highest loadings are from

measures of conductance change. For the purposes of the current study, a point of importance is that the conductance change measures are expected to load on a different factor from the amplitude measures. Substantially, though more distinctly for children, such is the case.

While there are variables other than 6 and 7 loading on Factor V for adults, their contributions are generally low and the variables themselves are complex with respect to their contribution to other factors. Accordingly, their contribution to Factor V will be ignored in this study.

The label Tonic Response given to Factor V is admittedly tentative. Insofar as conductance change, measured under certain conditions, may normally be taken as indicative of changes in arousal, then Factor V appears to have something to do with an arousal factor. It should be recalled, however, that amplitude is also a conductance change measure, but reflecting a more transitory change in arousal than the conductance change measure as defined in this study. Both measures, amplitude and conductance change, are indicative of changes in arousal, but the evidence of this study is that there is a distinct tendency for them to contribute to different factors. It seems possible then, that whereas Factor II represents phasic components of arousal, Factor V, with less certainty, represents tonic components of arousal.

Galvanic Skin Response Study--Nine Variables

Description of Analyses--Nine Variables

Since there was little evidence in the solutions previously described of latency and recruitment variables combining significantly with the remaining variables, the data were reanalysed with variables ten to nineteen removed. In the interests of parsimony, it was believed that analysis of the reduced number of variables might more clearly represent the associations and distinctions which exist among the important variables.

The statistical and interpretive procedures adopted to arrive at a solution for adults and for children were the same as those used in the study of nineteen variables. In the study of nine variables, three factors were extracted and the unrotated principal axes factors submitted to a series of oblique transformations with a range of values for $\underline{p}$ and $\underline{w}$. For both groups, the criterion of simple structure was best satisfied where both $\underline{p}$ and $\underline{w}$ were equal to one. This case represents the normal varimax solution. The varimax factor matrices are reported in Table 11 for adults and Table 12 for children.

Table 11

Varimax Factor Matrix for Adults (N = 40)

Nine Galvanic Skin Response Variables*

Variable Factor	I	II	III	h^2
1	477	-201	233	322
2	803	-014	-265	716
3	824	-017	138	698
4	661	-027	418	613
5	688	-085	-007	481
6	492	137	-056	264
7	-020	174	912	862
8	-013	989	077	985
9	-024	988	099	986
Sum of Squares	2.71	2.05	1.17	5.93

*Decimals have been omitted.

Table 12

Varimax Factor Matrix for Children (N = 37)

Nine Galvanic Skin Response Variables*

Variable Factor	I	II	III	h^2
1	855	238	213	833
2	767	-023	-145	610
3	850	-072	095	736
4	900	023	038	812
5	843	114	170	752
6	-063	-004	874	768
7	244	-147	775	682
8	063	986	-078	981
9	059	988	-071	985
Sum of Squares	3.63	2.04	1.48	7.16

*Decimals have been omitted.

Description and Discussion of Factors

Factor I--Phasic Response

Adults		Children	
3. Amplitude, task 4	.824	4. Amplitude, task 5	.900
2. Amplitude, task 3	.803	1. Amplitude, task 1	.855
5. Amplitude, task 6	.688	3. Amplitude, task 4	.850
4. Amplitude, task 5	.661	5. Amplitude, task 6	.843
6. Conductance change, task 4	.492	2. Amplitude, task 3	.767
1. Amplitude, task 1	.477		

For both groups, Factor I is defined by loadings from all of the available amplitude measures. The most obvious difference between groups is that whereas for children amplitude measures alone load on this factor, for adults the conductance change measure for auditory anagrams also has a moderate loading. It should be noted that this conductance change measure, along with variable 1, has a low communality in the solution for adults.

The contribution of variable 6 to Factor I for adults is perhaps best passed over in the current study. Certainly the correlation which exists between amplitude and conductance change on the auditory anagrams task for adults is not paralleled on the visual anagrams task.

Since amplitude measures have been used as representative of the phasic orienting response, and since amplitude measures have loaded on Factor I *independently* of the task and stimulus conditions, this factor is interpreted as a group factor representative of the

phasic response. Insofar as the evidence of this study is concerned, it appears that for the galvanic skin response, the phasic orienting response is comparable whether elicited by signal or non-signal stimuli, or by auditory or visual stimuli.

<u>Factor II</u>--Habituation

Adults		Children	
8. Habituation, # trials	.989	9. Habituation, # sec.	.988
9. Habituation, # sec.	.988	8. Habituation, # trials	.986

Factor II, in both groups, has loadings from habituation measures. Since the two measures are themselves interdependent measures, it is not surprising that they load on the same factor. More important is the fact that no further variables load on Factor II. Clearly, this factor represents habituation of the skin response, and presumably, of the orienting response itself.

<u>Factor III</u>--Tonic Response

Adults		Children	
7. Conductance change, task 5	.912	6. Conductance change, task 4	.874
4. Amplitude, task 5	.418	7. Conductance change, task 5	.775

Description of Factor III is based on the high loadings of the conductance change measures. For children, interpretation of the factor can be made with reference to conductance change measures only.

Discussion was directed to the distinction between arousal as represented by amplitude measures on one hand and conductance change measures on the other in the 19 variable study which preceded. In terms of that discussion, then, Factor III for children appears to represent the tonic aspect of the orienting response.

For adults, interpretation is clouded by the contribution of an amplitude measure to Factor III and by the absence of the second measure of conductance change. For the present, all that can be said is that there is inconclusive evidence concerning the isolation of a factor which represents the tonic reaction for adults. It is possible that in adults, some aspects of arousal have become dimensionalized as a function of the particular sense organs which are stimulated, but the evidence from this study is plainly not conclusive on this issue.

General Discussion of Factors

Correlations among the five oblique factors of the nineteen variable study are reported in Tables 9 and 10 for adults and children respectively. The correlations between factors are generally low, thus indicating that there is no strong departure from orthogonality. For adults, the greatest obliquity lies between Factors I and V, though the correlation here reaches only -0.208. It may be recalled that Factor I represented latency and recruitment measures while Factor V was defined principally by a loading from one of the conductance change measures, but less strongly by two

amplitude measures. It appears then that for adults, there might be some relationship between latency and recruitment measures on one hand, and some amplitude and recruitment measures on the other. There have been a few occasions within this study where latency and recruitment measures have raised interesting questions, and it appears that they might be worthy of further inquiry.

For children, the only correlation between factors which is worthy of note is that between Factors I and IV where the correlation is -0.230. The most striking commonality between these factors for children is the loading of recruitment scores on both factors. Contrary to the case for adults, in the children's group recruitment measures loaded on two different factors. Nevertheless, it is clear that these two factors are themselves related and hence the difference between groups is not as strong as it initially appeared.

It is interesting to recall that orthogonal solutions provided the simplest structure when latency and recruitment scores had been removed from the data. On theoretical grounds, it might have been supposed that obliquity would characterize factors which represented on one hand tonic, and on the other hand phasic aspects of the orienting response. Both tonic and phasic aspects of the response, in their different ways, represent arousal reactions, and Sokolov, too, has remarked upon their interrelatedness (Sokolov, 1963). This factor analytic study of the galvanic skin response, however, suggests a degree of distinctiveness between rate of habituation, amplitude and conductance change measures.

With regard to the composition of the factors themselves, both the study of nineteen variables and the further study of only nine variables point to a general similarity in the factor composition for adults and children. Indeed, to a considerable extent, the characteristics of the solution for one group are confirmed by those of the other group. There appears to be rather clear evidence of factors which are tentatively identified as the phasic response and rate of habituation, and less distinct evidence of a possible tonic factor.

Differences between the groups, leaving aside consideration of latencies and recruitment, primarily relate to the conductance change measures. For adults, there is some evidence that conductance change measures are not mutually related when different sense organs are stimulated. Rather, conductance change tends to be associated with amplitude measures for the same task. Since there was a failure in this respect in achieving replication between groups, clarification of the issues will await further research.

Lastly, it may be noted that in the study of nine variables, communalities for some of the variables in the adult sample were quite low. For children, the communalities were relatively higher. These observations may be taken to indicate that at least some variables in the adult sample had moderate loadings distributed over factors beyond the three extracted. In this sense, the relationships among the variables are more complex in the adult than in the children's sample.

Conclusions

In the light of the findings on both the nineteen and nine variable studies, hypotheses 1.1 and 1.2 are substantially confirmed. Three galvanic skin response factors have emerged which are tentatively described as phasic, tonic and habituation factors. The evidence in favor of the tonic factor, however, is not as certain in the adult as in the child sample. In the main, response measures load on these three factors relatively independently of whether or not the stimuli are presented in the auditory or visual mode. Furthermore, the three factors are identifiable in the samples of both children and adults.

CHAPTER VI

PUPILLARY RESPONSE STUDY--RESULTS AND DISCUSSION

Summary of Design

Pupillary responses were recorded concurrently with the galvanic skin responses discussed in the previous chapter. Six tasks were presented to all subjects, with successive stimuli being presented within each task. The dependent measures used in the analysis were arithmetic means, calculated for responses to all stimuli within a particular task, for _amplitude_, _base change_, and _latency_. On one of the six tasks, _rate of habituation_ only was computed, this being measured both as number of trials, and period of time to the habituation criterion.

Since the tasks employed were those already described for the skin response study they will be only briefly recapitulated here.

Task one presented five tones as non-signal stimuli, the response measures taken being _amplitude_ and _latency_. Task two was an habituation task for which _rate of habituation_ was measured as both time, and number of trials to criterion. Task three was designed to provide for dishabituation of orienting responses by the presentation of two further auditory stimuli, tones, which differed in pitch from those employed in tasks one and two. Response measures in task three were again _amplitude_, and _latency_. In task four there

was auditory presentation of four anagram problems, each preceded by the auditorily presented signal stimulus "Ready." Amplitude and latency measures were taken of the response to the "Ready" signal while base change measures were taken of the response to the anagram problem itself. Task five was comparable to task four except that both the "Ready" signal and the anagram problems were visually presented. The sixth task involved the presentation of five further auditory stimuli, pure tones, as signal stimuli for an imagined button press response to each tone. Response measures were amplitude and latency.

In all, fourteen response measures were taken over the six tasks. As in the galvanic skin response study, there were two groups of subjects, adults and children, and the measures for each group were separately submitted to statistical treatments which permitted the extraction and description of factors. In order to investigate both replicability and possible developmental differences between the groups, a comparison of the factor composition between adults and children was made.

Pupillary Response Study--Fourteen Variables

Description of Analyses--Fourteen Variables

Principal component analyses were carried out as described in the galvanic skin response study. The decision concerning the number of factors to be extracted was more problematic in the pupillary

study. Hypothesized factors were not clearly evident and the scree test could be taken to indicate the possible presence of seven interpretable factors for adults and six such factors for children. Furthermore, some variables were seen to be loading in any magnitude only on the sixth or seventh factors. In view of the investigatory nature of the study, it was decided to err in favor of more rather than few factors and seven were extracted for both groups.

Again in this study, the unrotated factors were subjected to oblique transformation using Hakstian's generalization of the Harris-Kaiser method. Many values of p and w were tried initially, those finally chosen being $p = 0.25$ and $w = 1.0$ for adults, and $p = 0.75$ and $w = 1.0$ for children.

Means and standard deviations of variables for the two groups are reported in Table 13. It should be noted (compare measures 8 and 9 from Table 4 with measures 1 and 2 from Table 13) that the rate of habituation of the pupillary response was slower than that of the galvanic skin response. Given this slower rate of habituation of the pupillary response, and the fact that the time interval between tones in the habituation study was constant following the presentation of the fifth tone, it may be expected that there will be greater interdependence between the two habituation measures in the pupillary study than there was in the galvanic skin response study.

Intercorrelations for the fourteen pupillary variables for adults are reported in Table 14, and for children in Table 15. It can be seen in these tables that particularly for the adult group,

Table 13

Means and Standard Deviations for Adults and

Children on Fourteen Pupillary Variables

Measure	Adults Mean	Adults S. D.	Children Mean	Children S. D.
1. Habituation--number of trials	23.525	11.914	30.649	17.884
2. Habituation--number of seconds	225.100	94.372	281.676	142.623
3. Amplitude--five pure tones	3.427	1.480	3.944	1.454
4. Latency--five pure tones	1.225	0.306	1.286	0.307
5. Amplitude--dishabituation, 2 pure tones	4.127	1.887	4.406	1.738
6. Latency--dishabituation, 2 pure tones	1.395	0.427	1.288	0.381
7. Amplitude--four auditory anagrams	3.531	1.487	4.242	1.476
8. Latency--four auditory anagrams	1.244	0.364	1.356	0.377
9. Base change--four auditory programs	5.897	3.448	5.968	2.924
10. Amplitude--four visual anagrams	3.108	1.898	3.036	1.104
11. Latency--four visual anagrams	0.858	0.464	1.112	0.492
12. Base change--four visual anagrams	3.326	2.999	2.433	3.117
13. Amplitude--five pure tones, imagined button press	4.311	1.580	4.994	2.222
14. Latency--five pure tones, imagined button press	1.497	0.270	1.474	0.250

Table 14

Intercorrelations for Fourteen Pupillary Variables for Adults (N = 40)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	--													
2	100	--												
3	13	12	--											
4	23	23	19	--										
5	-02	-02	15	-15	--									
6	13	13	10	15	18	--								
7	06	06	11	03	-11	10	--							
8	11	11	-07	26	-35	14	13	--						
9	-17	-18	14	22	16	00	39	-15	--					
10	04	04	-03	-02	02	-10	24	07	28	--				
11	21	21	17	03	18	00	06	31	-23	10	--			
12	-16	-16	-13	27	18	-08	16	-01	28	30	00	--		
13	-05	-05	39	29	-07	-07	22	10	35	00	03	15	--	
14	05	05	15	47	-33	-06	-02	44	05	-11	24	-01	52	--

*Decimals have been omitted.

Table 15

Intercorrelations for Fourteen Pupillary Variables for Children (N = 37)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	--													
2	100	--												
3	32	32	--											
4	19	19	09	--										
5	-14	-13	38	14	--									
6	-04	-04	-05	26	25	--								
7	-09	-09	26	-21	21	08	--							
8	-42	-41	-24	-14	20	20	30	--						
9	-19	-19	02	-02	23	21	62	25	--					
10	-07	-07	-14	13	26	23	13	-06	31	--				
11	-19	-19	08	18	35	33	20	07	17	37	--			
12	-08	-08	16	-09	14	12	15	30	24	47	27	--		
13	31	31	52	-01	35	-04	48	12	40	09	21	16	--	
14	-12	-11	15	03	17	33	29	31	15	-09	01	07	32	--

*Decimals have been omitted.

and to a lesser extent for children, intercorrelations among the measures are low. Indeed, tests of the significance of the correlations, as might be expected, showed that comparatively few were significantly different from zero. Accordingly, there is some hazard in subjecting the correlations to any kind of factorial analysis, since chance relationships may be expected to seriously influence the composition of factors. Nevertheless, if considerable caution is applied in the interpretation of the factorial structure, there may still be some value in an examination of the factor loadings in an exploratory study such as the current one. It is more for the hunches which the investigation might stimulate than for confirming evidence, that the analysis of the pupillary responses is undertaken.

Tables 16 and 17 record the oblique primary pattern matrices using the reported values of p and w. Communalities recorded in these two tables were abstracted from preliminary varimax solutions. Correlations among the seven oblique factors are represented in Table 18 for adults and in Table 19 for children.

As might be expected from examination of the two pattern matrices and the tables of correlations, a rotation of one solution to achieve maximum overlap with the other failed to demonstrate a more meaningful correspondence between the solutions for the two groups.

Description and Discussion of Factors

As in the galvanic skin response study, and to maintain continuity of method in reporting with that study, the factors will

Table 16

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.25, $\underline{w}$ = 1.0) for Adults (N = 40)

Fourteen Pupillary Variables*

Variable/Factor	I	II	III	IV	V	VI	VII	h^2
1	989	018	-011	-006	-005	024	003	985
2	988	018	-014	-006	-278	026	004	984
3	119	030	800	-244	-278	143	096	730
4	279	-206	273	637	288	-168	211	811
5	-052	-102	090	223	-842	332	204	847
6	013	039	-081	011	-036	-005	948	901
7	022	851	144	-168	160	-041	173	780
8	-048	119	-112	069	752	375	236	801
9	-117	482	365	286	-187	-342	048	744
10	094	652	-195	252	-048	209	-265	666
11	055	027	113	-007	011	914	-027	872
12	-135	148	-137	833	-144	076	-089	794
13	-092	079	803	105	131	-045	-111	755
14	-035	-236	493	199	589	138	-066	815
Variance Contribution	2.13	1.56	1.88	1.47	1.91	1.34	1.19	11.49

*Decimals have been omitted.

Table 17

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.75, $\underline{w}$ = 1.0) for Children (N = 37)

Fourteen Pupillary Variables*

Variable/Factor	I	II	III	IV	V	VI	VII	h^2
1	961	-035	084	-076	-020	-004	068	961
2	960	-033	086	-075	-016	-005	067	960
3	263	-006	850	021	003	-028	-072	823
4	141	-075	057	085	036	-075	900	882
5	-288	096	657	246	082	097	301	723
6	059	022	-192	525	678	015	221	841
7	-042	796	193	068	156	-031	-250	817
8	-463	202	-043	-347	449	440	067	805
9	-117	892	-054	076	004	100	129	859
10	040	247	-158	567	-225	489	172	786
11	-186	052	230	769	047	078	017	727
12	005	015	112	139	026	912	-112	905
13	297	508	576	-054	121	113	-034	785
14	-043	116	179	-088	817	-018	-056	752
Variance contribution	2.43	1.93	1.77	1.50	1.48	1.38	1.13	11.63

*Decimals have been omitted.

Table 18

Correlations Among the Seven Oblique Factors: Fourteen Pupillary Variables--Adults*

Factors	I	II	III	IV	V	VI	VII
I	---						
II	-024	---					
III	-038	-082	---				
IV	032	-185	-167	---			
V	083	-045	130	064	---		
VI	-153	029	-024	001	-077	---	
VII	123	-012	063	006	-000	045	---

* Decimals have been omitted.

Table 19

Correlations Among the Seven Oblique Factors: Fourteen Pupillary Variables--Children*

Factors	I	II	III	IV	V	VI	VII
I	---						
II	-029	---					
III	061	082	---				
IV	-027	042	029	---			
V	-045	067	041	007	---		
VI	-039	074	018	081	022	---	
VII	028	-027	005	093	032	-006	---

* Decimals have been omitted.

be described in the order in which they emerged in the solution for children. Specific variables are listed in order of the magnitude of their contribution to the factor.

Factor I--Habituation

Adults		Children	
1. Habituation, number of trials	.989	1. Habituation, number of trials	.961
2. Habituation, number of seconds	.988	2. Habituation, number of seconds	.960
		8. Latency, task 4	-.463

The two measures of rate of habituation define Factor I for both adults and children. The latency measure from task four, auditory anagrams, also loads on Factor I for children. Since this loading is not replicated in the adult sample, and since further latency measures from the children's sample fail to load on this factor, the sole latency measure is probably best ignored.

A principal point of interest about Factor I is that neither the amplitude nor the base change measures load on this factor. On the basis of the loadings listed above, it appears that the rate of habituation of the pupillary response to auditory stimuli is relatively independent of the pupillary responses represented by amplitude and base change. It may also be noted in passing that for both groups, Factor I makes the greatest variance contribution of all the factors.

Factor I, then, is identified as an habituation factor which appears strongly in the solutions for both groups.

Factor II--Pupillary Response to Signal Stimuli

Adults			Children		
7.	Amplitude, task 4	.851	9.	Base change, task 4	.892
10.	Amplitude, task 5	.652	7.	Amplitude, task 4	.796
9.	Base change, task 4	.482	13.	Amplitude, task 6	.508

While Factor II includes variables 7 and 9 for both groups, the loadings listed above provide evidence that the factor for adults is not entirely consistent with that for children. Perhaps the most important characteristic of the factor is the fact that both amplitude and base change on the auditory anagrams task load on the same factor. This association is paralleled on Factor VI for children where the amplitude and base change measures on the visual anagrams task also load on one factor. The analyses suggest, then, that base change and amplitude are not strongly independent, and that consequently, the two measures do not reflect distinct phases of the orienting response.

A further interesting characteristic of the loadings, at least for adults, is that the amplitude variables from both the auditorily and visually presented anagram tasks load on the same factor. A possible implication of this observation is that for adults in contrast to children, pupillary responses are not dimensionalized in terms of modality of sensory stimulation.

The seemingly common feature among the loadings on Factor II is that all variables are response measures to signal stimuli. Thus, the factor is currently labelled in terms of this common aspect.

Factor III--Pupillary Response to Simple Auditory Stimuli

Adults			Children		
13.	Amplitude, task 6	.803	3.	Amplitude, task 1	.850
3.	Amplitude, task 1	.800	5.	Amplitude, task 3	.657
14.	Latency, task 6	.493	13.	Amplitude, task 6	.576

As is the case throughout the pupillary study, the name of this factor is admittedly speculative. Measures 3 and 13, amplitude measures to non-signal and signal auditory stimuli respectively, load on Factor III for both adults and children. Indeed, three amplitude measures (3, 5 and 13) contribute to the definition of this factor for children, and all are response measures to simple auditory stimuli. The amplitude measures, it will be recalled, represent the short lasting, transitory increases in pupillary dilation in response to stimulus change. Had four or five of the amplitude variables loaded on Factor III there might have been a case for arguing that it represented the phasic aspect of the orienting response. But with only three such measures loading on Factor III for children, and two for adults, such a proposition is seriously weakened. Furthermore, in the light of Factor II on which both amplitude and base change measures on the same task load on the one factor, the evidence appears to be contrary to the notion that pupillary responses are representing, in any direct or unidimensional fashion, phasic or tonic orienting responses.

In the adult sample, the association between variables 13 and 14 might be taken as evidence that amplitude and latency of the

pupillary response are functionally related, but taking the factor matrices for adults and children as a whole, there is only very occasional evidence of such a relationship. On these grounds, the contribution of variable 14, latency, to Factor III for adults will not be further considered.

In general then, Factor III is described in terms of pupillary responses to simple auditory tone stimuli. It represents response measures to both signal and non-signal stimuli, but has no loadings from either the auditory or the visual anagram tasks. It appears possible that the factor might be specific to the physical characteristics of the stimulus (tones as opposed to words), but further evidence would be required to support such a proposition.

<u>Factor IV</u>--Indeterminate

<u>Adults</u>

12.	Base change, task 5	.833
4.	Latency, task 1	.637

Since Factor IV for adults has no loadings in common with Factor IV for children, the description of factors for the two groups will be separately presented.

For adults, Factor IV is defined by loadings from base change on the visual anagrams task and the latency of the pupillary response to the pure tones presented in task 1. As may be seen from the correlation between the two variables (Table 14), the direct association

between variables is represented by a correlation of only 0.27. Examination of the primary pattern matrix reveals further that variable 4 has loadings upward of .20 on all but one of the seven factors extracted (see Table 16). Thus, it seems likely that the contribution of the latency measure to Factor IV has a stronger chance than definitive psychological basis. If the contribution of the latency measure is discounted, then Factor IV for adults appears to be a specific factor and principally a function of base change on the visual anagrams task.

Factor IV--Indeterminate

Children

11.	Latency, task 5	.769
10.	Amplitude, task 5	.567
6.	Latency, task 3	.525

Of the three variables loading on Factor IV, variable 11, latency on the visual anagrams task, is the only variable not characterized by complexity. With two of the three measures from task 5 loading on this factor, it is possible that the factor might represent, in some degree, an effect of either task or modality of sensory stimulation, or even both. In terms of the data available in this study, however, interpretation of this factor is not warranted.

Factor V--Latency of response to auditory stimuli

Adults			Children		
5.	Amplitude, task 3	-.842	14.	Latency, task 6	.817
8.	Latency, task 4	.752	6.	Latency, task 3	.678
14.	Latency, task 6	.589	8.	Latency, task 4	.449

While there is no identity in the composition of the factor for the two groups, there is still a degree of similarity. The latency measures on tasks four and six, both tasks involving the presentation of auditory stimuli, are common to the factor for adults and for children. For adults, Factor IV has the distinctive characteristic of the negative loading of the amplitude of the dishabituated pupillary response. From Table 14 it can be seen that the amplitude measure, variable 5, is correlated a little beyond the .30 level with both of the latency measures, but the two latency measures are themselves more highly intercorrelated. For the sample of adults used in the current study it appears that the amplitude of the dishabituated response to auditory stimuli might be related to the latency of the response to signal auditory stimuli, but such a possibility would require further confirmation before it could be seriously entertained.

For children the factor appears a little more clear cut. All loadings on Factor V for children represent latency of the pupillary response where auditory stimuli are involved. There is no loading from latency in task one, and this observation might be taken to suggest that the latency of the dishabituated response is more like the latency of the response to signal than it is to non-signal stimuli.

If similarity between the factor loadings for adults and children is stressed, then Factor V appears to represent a latency factor where auditory stimuli have been presented.

As may be determined from inspection of Tables 16 and 17, Factors VI and VII for adults and Factor VII for children are essentially specific factors with loadings of any magnitude from one variable only. These factors will not be discussed. The remaining factor of possible interest is Factor VI for children

Factor VI--Pupillary response to visual signal stimuli

Children

12.	Base change, task 5	.912
10.	Amplitude, task 5	.489
8.	Latency, task 4	.440

Variable 12, base change on the visual anagrams task, is the only variable loading on Factor VI which is not complex. Variable 10, amplitude on the visual anagrams, has a higher loading on Factor IV where it is associated with latency on the same task. Variable 8, latency on the auditory anagrams has higher loadings on Factors I and V. The factor is, however, somewhat comparable with Factor II on which base change is associated with amplitude for the auditory anagrams task. The composition of Factor VI lends further support to the possibility that both task conditions and modality of stimulation influence the pupillary response for children.

Summary of the Fourteen Variable Study

The study of the fourteen pupillary variables lends little support to the notion that pupillary responses, as measured in the current study, reflect the functioning of orienting responses in any unidimensional sense. There is evidence that the pupillary response to auditory stimuli can be habituated, and that habituation is substantially independent of other response events.

The correlation tables and the pattern matrices reveal that the various response measures, made under varying conditions of task and sensory modality of stimulation, do not hang together in a notably general or unidimensional manner. Indeed, the comparatively large number of factors which had to be extracted to arrive at relatively high communalities for all variables, and the fact that no factors made very high variance contributions, indicate that comparative specificity rather than generality characterizes the relationship among the variables.

Of the four response measures used, the latency measures are the least systematic in their loadings on factors. Especially for children, there is more complexity in factor loadings associated with latency than with amplitude or base change measures. Furthermore, the latency variables occasionally load on factors along with amplitude and base change measures, but independently of tasks. Despite the complexity, however, there is some evidence of a factor, Factor V, which is representative of latency alone.

Except with respect to the visual anagram task for adults,

the base change measures are represented on various factors along with the amplitude measure taken on the same task. It appears that the longer term changes in pupillary dilation go hand in hand with the more fleeting response changes. There is some evidence of a functional relationship among the remaining amplitude measures, that is those not derived from the anagram tasks. It seems, however, that either or both task and stimulus characteristics stand in the way of any overall association among all amplitude measures.

Pupillary Response Study--Nine Variables

Description of Analyses--Nine Variables

As with the galvanic skin response study, there was little evidence in the pattern matrices that the latency variables were systematically related to the variables of central concern. With a view to examining the relationship among habituation, amplitude and base change measures, uncluttered by latency measures, a further study of the pupillary response was undertaken, this time with the latency measures removed.

The statistical and interpretive procedures employed to arrive at solutions characterized by the least complexity were the same as those described in the previous studies. Four factors were extracted for each group. With only nine variables involved, the seeming presence of four factors suggests that the component analysis achieved only moderate parsimony among the variables.

Table 20

Oblique Primary Pattern Matrix (p = 0.25, w = 1.0) for Adults (N = 40)

Nine Pupillary Variables*

Variable/Factor	I	II	III	IV	h^2
1	990	-004	-000	-007	981
2	990	-004	-003	-007	981
3	162	201	817	-212	730
5	042	911	102	198	873
7	117	-454	296	501	609
9	-163	003	430	581	636
10	165	-081	-165	758	581
12	-134	209	-105	719	580
13	-099	-160	789	049	676
Variance contribution	2.09	1.15	1.62	1.78	6.64

*Decimals have been omitted.

Table 21

Oblique Primary Pattern Matrix (p = 0.50, w = 1.0) for Children (N = 37)

Nine Pupillary Variables*

Variable/Factor	I	II	III	IV	h^2
1	982	-046	025	-002	974
2	982	-045	027	-002	974
3	260	056	810	-111	789
5	-294	-001	803	203	751
7	-053	877	097	-058	803
9	-139	853	-089	193	817
10	-005	083	-079	880	797
12	001	030	132	792	665
13	342	551	463	017	754
Variance contribution	2.25	1.90	1.64	1.54	7.33

*Decimals have been omitted.

Table 22

Correlations Among the Four Oblique Factors:

Nine Pupillary Variables--Adults*

Factors	I	II	III	IV
I	---			
II	-029	---		
III	007	-023	---	
IV	-080	-017	146	---

* Decimals have been omitted.

Table 23

Correlations Among the Four Oblique Factors:

Nine Pupillary Variables--Children*

Factors	I	II	III	IV
I	---			
II	-025	---		
III	103	181	---	
IV	-063	130	061	---

* Decimals have been omitted.

For adults, simplest structure was attained where $\underline{p}$ = 0.25 and w = 1.0. The corresponding values for children were 0.50 and 1.0 respectively. These values indicate that there was some obliquity among the factors and that the larger variance contribution was carried by the first factor or two extracted. The pattern matrix for adults is reported in Table 20 for adults and in Table 21 for children. Correlations among the four oblique factors are recorded in Tables 22 and 23 for adults and children respectively.

Description and Discussion of Factors

Factor I--Habituation

Adults		Children	
1. Habituation, number of trials	.990	1. Habituation, number of trials	.982
2. Habituation, number of seconds	.990	2. Habituation, number of seconds	.982

Factor I has emerged clearly as representing rate of habituation for both groups. For the pupillary response, variables 1 and 2 are so highly interrelated that there is significant redundancy between the two measures. What is more important is the fact that neither amplitude nor base change measures load on this factor.

Factor II--Specific

Adults

5.	Amplitude, task 3	.911
7.	Amplitude, task 4	-.454

Since there is almost no overlap in the composition of Factor II for adults and children, the factor will be separately described for the two groups.

The principal loading on Factor II for adults is the amplitude measure from the dishabituated pupillary response. There is a rather low negative loading from amplitude measures taken on the auditory anagrams task, but the negative association between two amplitude measures is not characteristic of the data. The variance contribution of Factor II for adults is the smallest of the four factors extracted, and the factor appears largely specific with respect to variable 5.

Factor II--Pupillary Response to Auditory Signal Stimuli

Children

7.	Amplitude, task 4	.877
9.	Base change, task 4	.853
13.	Amplitude, task 6	.551

The three variables loading on Factor II have in common the fact that all are response measures to auditory signal stimuli.

Variable 13, amplitude on the "imagined" button press task is complex since the same variable has a slightly smaller loading on Factor III. For children then, Factor II seems to indicate some functional relationship between the pupillary response and the characteristics of auditory signal stimuli.

It is worth noting that both amplitude and base change measures from task four have high loadings on Factor II. The short (amplitude) and long term (base change) measures of the pupillary response are closely associated on this factor, this being contrary to the outcome for equivalent measures in the skin response study. It may be noted further that the base change and amplitude measures from task five for children also load together on Factor IV. Factors II and IV for children in this study support the loadings of the fourteen variable study in which amplitude and base change, for auditory and visual anagrams respectively, loaded on separate factors. Since the stimuli for tasks four and five differed in modality of sensory stimulation rather than in meaning, it appears that for children there might be an effect of modality upon the pupillary response.

<u>Factor III</u>--Pupillary Response to Auditory Stimuli

Adults			Children		
3.	Amplitude, task 1	.817	3.	Amplitude, task 1	.810
13.	Amplitude, task 6	.789	5.	Amplitude, task 3	.803
9.	Base change, task 4	.430	13.	Amplitude, task 6	.463

Factor III for adults is comparable with Factor III for children, though the factors are not identical in composition. The amplitude measures of response to the non-signal and signal tone stimuli, tasks one and six, load on Factor III for both groups. The difference between these two tasks lies in the instructional conditions relating to the tasks. The similarity between the tasks lies in the identity between the auditory stimuli, tones, used in the two tasks.

The two measures which make least contribution to Factor III are base change on auditory anagrams for adults, and amplitude on the "imagined" button press task for children. Both of these measures have further loadings on other factors.

If the overlap between the loadings for adults and children is stressed, then Factor III may be seen as representing pupillary responses to auditory stimuli. There is similarity in the loadings on this Factor, though not identity, when compared with the loadings on Factor III in the fourteen variable study. Possible differences in the nature of responses for adults and children will be considered in relation to the following factor and in the general discussion at the conclusion of this chapter.

Factor IV--Pupillary Response to Verbal Stimuli

Adults

10.	Amplitude, task 5	.758
12.	Base change, task 5	.719
9.	Base change, task 4	.581
7.	Amplitude, task 4	.501

Factor IV for adults and children share two variables in common, but nevertheless, the essential character of the factors for the two groups appears to be different and the factors will be discussed separately.

It should be remembered that the amplitude measure was made upon the response given to the "Ready" signal which preceded the anagram stimulus itself, and was a phasic-like measure of a short lasting response. By contrast, base change was a measure of a longer lasting response to the presentation of the anagrams. Thus, in the pupillary study we are finding rather consistent evidence that the transitory and the longer term response measures, even though elicited by different stimuli, are associated in terms of task.

For adults, amplitude and base change measures from both the auditorily and visually presented anagrams load on the same factor. This observation is in direct contrast to the case for children (see Factors II and IV) for whom the amplitude and base change measures pair up according to task, but the tasks themselves load on separate factors. Apparently modality of sensory stimulation has a stronger effect upon the pupillary response of children than it does upon the adults' response.

The descriptive title of Factor IV for adults is again problematic. From the data available, it cannot be certain whether it is the verbal nature of the stimuli on the anagram tasks which accounts for the grouping of variables, or alternatively, the grouping might

be a function of the amount of information conveyed by the stimuli, assuming that the verbal stimuli have greater information content than the simple tone stimuli. These and other possibilities will be further considered when the description of factors in this study is complete.

Factor IV--Pupillary Response to Visual Signal Stimuli

Children

10.	Amplitude, task 5	.880
12.	Base change, task 5	.792

Factor IV for children is specific with respect to the visual mode of stimulation, and as is characteristic in this study of pupillary responses, amplitude and base change measures on the same task are loading together. The factor appears to represent the pupillary response to visual signal stimuli.

General Discussion of Factors

In comparison with the study of fourteen variables, the second study, of nine pupillary variables, seems to achieve a little more clarity concerning the relationship among the three central response measures. For adults, in the nine variable study, there appear to be three important factors, I, III, and IV. The first of these is an habituation factor and is interpretable without debate. Neither Factor III nor Factor IV seems directly interpretable in terms of independent phasic and tonic orienting responses. The association

of amplitude measures with base change confounds such a possibility. Furthermore, there is not the same consistency in loadings of all possible amplitude measures on the one factor as was the case in the galvanic skin response study.

Another interesting point about the association of amplitude and base change measures bears upon the interpretation of the response in functional terms. The point, indeed, is relevant to both adults and children. Kahneman and others (Kahneman & Beatty, 1966; Kahneman, Beatty, & Pollack, 1967) have interpreted the pupillary response in terms of memory and processing load. According to their view, the magnitude of pupillary dilation in response to the "Ready" signal would be less than that in response to the anagram problems themselves. Inspection of the relevant means for the amplitude and base change measures for adults and children given in Table 13 (page 74) lends some credence to Kahneman's position, at least with respect to the auditory anagrams in which a memory load is imposed upon subjects. Yet it is interesting to note that despite the difference in mean value between amplitude and base change on the auditory anagrams, the amplitude measure loads on the same factor as the base change measure, and not on the same factor as the amplitude of the response to the signal stimulus given in task 6. The "memory load" imposed by the "Ready" signal for an anagram problem could hardly be considered substantially different from the load imposed by the signal tone stimulus in task 6, yet the correlation between amplitude and

base change on anagrams is higher than the correlation between the amplitude on task 4 and the equivalent measure on task 6.

A proposal somewhat distinct from Kahneman's interpretation of the pupillary response is that pupillary dilation might be a function of the amount of information processing occuring as a function of some stimulus (Boersma, Wilton, Barham, & Muir, 1970). Berlyne (1970) has used the expression degree of attentiveness to refer to such a variable. In terms of the current study, it might be assumed that the degree of attentiveness determined by the simple auditory tone stimuli, whether they held signal or non-signal value, might be less than the attentiveness demanded either by the anagram tasks or even the "Ready" stimulus signalling the onset of anagram presentation. This view is consistent with the pattern of loadings in the current study in which variables 3 and 13, amplitude of response to the non-signal and signal tone stimuli respectively, load on Factor III, but variables 7 and 9, amplitude and base change for the auditory anagram tasks, load together on a different factor.

In terms of this proposal, then, Factors III and IV for adults might be hypothesized as representing different degrees of attentiveness, the different levels being a function of the overall stimulus characteristics of the various tasks.

The discussion to this point has focused principally upon the interpretation of factors in the solution for adults. The proposed interpretation is also accommodated by the factor loadings in the children's group where four factors appear to be meaningful. Factor I,

as with the adults, is an habituation factor. Factors II and IV represent the two pupillary response measures from tasks four and five respectively. The separation of these response measures onto two factors in relation to task might represent the greater attentiveness required of children in remembering the letters of the anagrams in the aural as distinct from the visual presentation. (Compare the means for children on variables 7 and 10 on Table 13, page 74.) It would have to be assumed that an equivalent challenge to memory on the auditory task was not present for the adult subjects. Factor III for children, on the other hand, represents loadings from response measures to the simple tone stimuli, both signal and non-signal.

There is yet another possible interpretation of factor loadings in the pupillary study which is not necessarily inconsistent with the interpretation in terms of attentiveness just presented. Pupillary dilation as a response to a violation of expected stimulus input is commonly identified as an orienting response. If it may be assumed that the amplitude measure did in fact reflect a phasic orienting response, and that the base change measure reflected, at least in some degree, the tonic response, then the data could be taken to support two propositions which have been identified in the literature.

The first of these propositions is that the tonic and phasic aspects of the orienting response are themselves related (Sokolov, 1963). The loading of the amplitude measures on the same factors as the base change measures could be taken as support for this notion.

The second proposition is that arousal might be a dimensionalized variable (Berlyne, 1967; Lacey, 1967; Taylor & Epstein, 1967). Bearing in mind that the orientation reaction is a particular case of arousal, then the fact that the amplitude measures load somewhat systematically on different factors might be taken as support for the view that arousal is indeed not a unidimensional variable, but rather is dimensionalized as a function of stimulus and task conditions.

A somewhat attractive possibility might be that, in the case of the pupillary response, the dimensionality in arousal might be a function of the degree of attentiveness, that is the amount of information being processed as a function of some particular stimulus. At least within moderate ranges of arousal, it seems reasonable that attentiveness would have some, not necessarily linear, relation with degree of arousal.

Clearly enough, on the basis of factor analysis alone, choice between the various interpretations of loadings cannot be strongly determined by the data. Experimental designs will have to be applied in testing hypotheses which discriminate sharply between memory load, attentiveness and arousal interpretations of the pupillary response. For the present, however, it may be noted that the solution for adults bore some clear parallels with the solution for children, but that the factors represented some relationships among variables which contrast clearly with the outcomes of the galvanic skin response study.

The correlations among the oblique factors, both in the fourteen variable study (Tables 18 and 19, page 97) and in the nine variable study (Tables 22 and 23, page 108) indicate that there is no strong obliquity among the factors. The oblique solutions actually selected provided for simpler structure of factor loadings than did orthogonal solutions but the relationship among the factors is still not characterized by any sharp obliquity.

Conclusions

In view of the findings on both the fourteen and the nine variable studies, hypotheses 2.1 and 2.2 are not substantially confirmed. A distinct factor which might represent habituation was identified, but no factors representative of unidimensional and separate phasic and tonic aspects of the orienting response could be identified. Rather, factors represented pupillary responses to differing stimulus and task conditions, and it has been suggested that these factors might be indicative of either: (a) attentiveness as determined by the nature of the stimulus conditions; or (b) orienting responses dimensionalized in terms of degree of attentiveness. The second of these propositions is most consistent with the body of literature on both the orientation reaction in particular, and arousal in general. There was no overall close replication between solutions for the two groups, but at the same time, some distinct parallels between factor loadings for adults and children were noted.

CHAPTER VII

EYE-MOVEMENT STUDY--RESULTS AND DISCUSSION

Summary of Design

Eye movements were photographed during the presentation of five tasks. Each task involved the presentation of three successively presented stimulus figures. The dependent measures used in the analysis were the arithmetic means for Tracklength, number of Refixations, Information Search Score and number of Unscored Frames, each being computed from observations made over the three stimulus figures in any particular task. Except for task 2, eye-movement measures used in the analysis were derived from the first three seconds of viewing the stimulus figures.

Task 1 was a _non-directed_ search task in which subjects were given the opportunity to view picture characterizations of people in relatively unfamiliar dress and situations. No instructions were given with respect to the response which subjects should make. Task 2 was a _prolonged search_ task, also non-directed, in which eye-movement recordings were taken for the final three seconds of sixty seconds of continuous viewing. Stimulus figures were similar to those used in task 1. Task 3 was a further _non-directed_ search task. The stimulus figures for task 3 comprised three pairs of drawings of geometric figures in which one member of each pair was a regular and familiar arrangement of elements, and the other member of the pair was an ir-

regular arrangement of the same elements. No information search score was derived for this task. Task 4 involved the successive presentation of three figures from the incomplete pictures sub-test of the Wechsler Adult Intelligence Scale. In this directed search task subjects were instructed to identify and report the missing part of the picture. Subjects were given up to thirty seconds to solve the problems in task four, but only the first three seconds of viewing were used as data for this study. Task five comprised a further directed search task in which subjects were instructed to recall and report as many details of the figures as possible following a five-second presentation of each figure. The three figures were selected from the same source and were similar to those used in the first two tasks.

In all, both for adults and for children, nineteen response measures were derived from performance on five tasks and the measures for the two groups were then separately subjected to factor analytic treatments which permitted the making of comparisons between the groups.

Description of Analyses--Nineteen Eye-Movement Variables

Preliminary principal component analyses were carried out to permit inspection of the eigenvalues, communalities and variance contributions of the different factors. With no specific hypotheses concerning the primary factor pattern, a decision concerning the number of factors to be extracted was more problematic than in the previous two studies. Both groups had seven eigenvalues greater than one. The scree test could be interpreted as warranting the extraction of five

factors for adults but seven for children. Since the magnitude of the communalities for some variables tended to diminish seriously when fewer than seven factors were extracted, this combined evidence, together with overall concern for interpretability, led to the extraction of seven factors for each group.

The unrotated factors were subjected to oblique transformation, again using Hakstian's generalization of the Harris-Kaiser method. A range of values for $\underline{p}$ and $\underline{w}$ were initially employed, those finally selected being $\underline{p} = 0.25$ and $\underline{w} = 3.5$ for adults, and $\underline{p} = 0.0$ and $\underline{w} = 7.0$ for children. The value of $\underline{p}$ employed for children produces a transformation which represents the special case of the Independent Cluster Solution.

Means and standard deviations of variables for the two groups are reported in Table 24. It may be noted that there is seeming evidence in this table of effects of task and stimulus conditions upon various dependent measures. Furthermore, task-related variation among the means is substantially paralleled within each of the two groups. On the basis of a mere visual inspection of this data it appears that task effects may be stronger than group effects. This possibility could be explored in a further study through the application of an analysis of variance design to the data.

Intercorrelations for the 19 eye-movement variables are reported in Table 25 for adults and in Table 26 for children. Tables 27 and 28 report the oblique primary pattern matrices. Communalities recorded in these two latter tables were taken from preliminary varimax solutions. Correlations among the seven oblique factors are reported in

Table 24

Means and Standard Deviations for Adults and Children

on Nineteen Eye-Movement Variables

Measure	Adults Mean	Adults S.D.	Children Mean	Children S.D.
1. Trk.[1]--task 1 non-directed search,pictures	12.749	3.984	12.486	2.868
2. Trk.--task 2 prolonged search, pictures	7.003	3.011	6.396	3.813
3. Trk.--task 3 non-directed search, figures	9.723	2.664	9.319	2.588
4. Trk.--task 4 directed search, incomplete pictures	15.538	3.408	14.307	3.457
5. Trk.--task 5 directed search, recall pictures	13.784	3.021	13.511	2.699
6. Nrfix.[2]--task 1 non-directed search,pictures	11.183	2.883	12.018	2.160
7. Nrfix.--task 2 prolonged search, pictures	7.921	2.834	7.586	3.690
8. Nrfix.--task 3 non-directed search,figures	10.108	2.356	10.225	2.781
9. Nrfix.--task 4 directed search, incomplete pictures	12.300	2.334	11.770	2.091
10. Nrfix.--task 5 directed search, recall pictures	11.542	1.730	12.694	2.591
11. ISS[3]--task 1 non-directed search,pictures	109.826	11.686	108.276	11.570
12. ISS--task 2 prolonged search, pictures	96.551	20.385	80.577	22.993
13. ISS-task 4 directed search,incomplete pictures	91.349	14.173	90.282	13.378
14. ISS-task 5 directed search,recall pictures	109.244	9.517	109.397	11.398
15. Usf.[4]--task 1 non-directed search,pictures	1.142	1.150	1.131	1.354
16. Usf.--task 2 prolonged search,pictures	3.125	3.428	6.081	5.960
17. Usf.--task 3 non-directed search,figures	0.450	0.669	0.586	0.686
18. Usf.--task 4 directed search,incomplete pictures	1.037	1.321	1.378	1.727
19. Usf.--task 5 directed speech,recall pictures	0.846	0.844	1.113	1.255

1. Trk. -- Tracklength
2. Nrfix.-- Number of refixations
3. ISS-- Information search score
4. Usf.-- Unscored frames

Table 25

Intercorrelations for Nineteen Eye-Movement Variables for Adults (N = 40)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	--																		
2	29	--																	
3	33	05	--																
4	28	08	21	--															
5	32	05	41	50	--														
6	82	24	35	18	23	--													
7	23	81	06	-12	-05	34	--												
8	04	02	74	13	10	23	12	--											
9	26	16	04	64	13	39	10	05	--										
10	34	10	25	30	55	52	31	15	24	--									
11	-15	-06	-49	03	-33	-08	-03	-35	22	-13	--								
12	-15	-24	-00	13	19	-03	-04	08	11	21	09	--							
13	-33	-34	-13	-18	-12	-26	-29	-09	-14	-16	20	16	--						
14	-13	-20	-47	-07	-33	-06	-07	-21	07	-10	54	-05	17	--					
15	18	17	34	-21	-01	22	17	07	-18	07	-46	-11	-02	-42	--				
16	07	-01	11	-01	-08	06	-13	09	-07	-09	-27	-60	-10	-02	23	--			
17	02	14	48	-00	02	12	22	54	06	28	-38	06	-01	-25	21	03	--		
18	28	-08	22	18	15	17	01	19	-05	13	-27	-15	-45	-18	08	28	-04	--	
19	-02	06	43	13	15	05	10	29	07	04	-43	12	-14	-53	37	23	26	27	--

*Decimals have been omitted.

Table 26

Intercorrelations for Nineteen Eye-Movement Variables for Children (N = 37)*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	--																		
2	06	--																	
3	07	21	--																
4	14	-07	03	--															
5	15	39	32	15	--														
6	67	22	23	07	19	--													
7	-06	86	40	-09	42	11	--												
8	-03	08	77	10	40	30	26	--											
9	23	05	13	64	22	36	11	30	--										
10	-19	29	32	04	69	20	40	58	28	--									
11	-37	-23	-19	-05	-20	-30	00	-15	08	13	--								
12	-02	-13	22	-07	-20	-15	09	09	10	-13	29	--							
13	36	-11	-12	02	-16	05	-02	-26	01	-45	08	13	--						
14	-02	-22	14	05	-22	16	-02	11	21	-15	18	39	30	--					
15	16	28	14	07	35	25	16	27	09	19	-47	-17	06	03	--				
16	26	02	-09	03	25	39	-20	06	07	25	-38	-69	-15	-27	20	--			
17	-06	04	43	-10	24	20	15	61	08	52	02	-11	-39	-07	24	24	--		
18	02	52	-04	-12	35	22	22	01	-03	29	-28	-36	-49	-49	17	34	-00	--	
19	05	04	15	-14	28	-09	-00	24	-07	28	-07	-22	-19	-60	-11	14	35	18	--

*Decimals have been omitted.

Table 27

Oblique Primary Pattern Matrix (p = 0.25, w = 3.5) for Adults (N = 40)

Nineteen Eye-Movement Variables*

Variable Factor	I	II	III	IV	V	VI	VII	h^2
1	-098	055	-149	858	052	010	-093	814
2	-087	896	-081	039	128	-159	000	872
3	631	-144	-019	248	037	-318	-029	794
4	-022	-135	056	069	860	-116	-126	857
5	-141	-273	383	424	221	-421	-136	705
6	136	116	-100	872	055	138	044	851
7	107	893	123	123	-118	031	-070	891
8	939	-044	001	-049	028	085	-145	860
9	059	157	-077	103	872	116	158	833
10	136	012	369	636	039	011	-049	632
11	-206	099	069	-101	233	646	126	700
12	075	-105	829	-075	046	-071	077	745
13	052	-346	018	-030	-052	040	754	750
14	033	-130	-125	135	-066	887	055	741
15	-055	109	-240	290	-298	-641	331	721
16	068	-182	-841	037	081	-141	-056	774
17	795	179	037	-030	-028	-054	172	708
18	041	-183	-118	083	-082	-087	-806	765
19	167	065	-061	-278	235	-728	-048	671
Variance contribution	2.21	2.06	1.86	2.50	1.87	2.67	1.56	14.68

*Decimals have been omitted.

Table 28

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.00, $\underline{w}$ = 7.0) for Children (N = 37)

Nineteen Eye-Movement Variables*

Variable Factor	I	II	III	IV	V	VI	VII	h^2
1	-037	-005	-042	931	053	-164	-027	893
2	-163	976	002	048	-029	-011	-078	911
3	770	118	410	122	-035	-066	-179	761
4	-220	-202	075	-110	966	-062	-165	869
5	230	388	-057	-025	357	-264	-136	647
6	293	163	-449	731	-022	324	166	906
7	072	933	289	011	007	035	045	890
8	910	-065	131	-029	127	007	-121	875
9	056	026	-042	183	821	133	227	839
10	545	294	-292	-233	240	003	264	826
11	-026	022	132	-147	079	123	780	786
12	167	079	725	092	-041	131	167	668
13	-315	-052	475	522	022	-023	-160	637
14	209	-108	170	065	-009	818	022	841
15	171	113	-089	-140	082	227	-763	727
16	099	-201	-863	162	005	029	-057	806
17	874	-171	-200	-072	-147	-001	076	737
18	-184	541	-579	-097	-062	-089	046	724
19	300	-131	104	142	-038	-917	120	877
Variance contribution	3.04	2.56	2.51	1.91	1.86	1.83	1.52	15.22

*Decimals have been omitted.

Table 29 for adults and in Table 30 for children.

Description and Discussion of Factors

As in the previous studies, factors will be described in the order in which they emerged in the solution for children. For each factor, loadings will be presented in decreasing order.

Factor I--Task Three

Adults			Children		
8.	# refixations, task 3	.939	8.	# refixations, task 3	.910
17.	Unscored frames, task 3	.795	17.	Unscored frames, task 3	.874
3.	Tracklength, task 3	.631	3.	Tracklength, task 3	.770
			10.	# refixations, task 5	.545

The three variables common to the solution for adults and children are the only three measures taken on task three. It appears from the composition of this factor, and the observation is supported by the nature of the loadings on further factors, that much of the variance among the variables is attributable to the tasks and stimulus figures themselves.

The association of mean number of Unscored Frames with the Tracklength and Refixation variables is not characteristic of the composition of the remaining factors. The only further exception occurs in Factor VI for adults in which a reasonably high loading of Unscored Frames on task five is associated with a moderate loading of Tracklength on the same task. As may be seen from inspection of the correlation tables, the correlation between Unscored Frames and number of Refixations is unusually high compared with the equivalent correlation on

Table 29

Correlations Among the Seven Oblique Factors: Nineteen Eye-Movement Variables--Adults*

Factors	I	II	III	IV	V	VI	VII
I	---						
II	050	---					
III	016	-036	---				
IV	179	182	021	---			
V	046	011	144	225	---		
VI	-340	-035	055	-177	027	---	
VII	-080	-045	113	-209	-134	176	---

* Decimals have been omitted.

Table 30

Correlations Among the Seven Oblique Factors: Nineteen Eye-Movement Variables--Children*

Factors	I	II	III	IV	V	VI	VII
I	---						
II	313	---					
III	-136	-179	---				
IV	-007	-009	-064	---			
V	250	130	-089	172	---		
VI	-119	-159	348	150	089	---	
VII	-094	-181	260	-279	-060	026	---

* Decimals have been omitted.

other tasks. The author is unable to account for the higher correlation which characterizes task three, for both adults and children, but it seems reasonable to assume that the characteristics of the stimulus figures themselves might in some way account for the relationship.

The contribution of variable 10, number of Refixations on task five, to Factor I for children is also atypical of the overall pattern of loadings on other factors. Since there are no psychological or logical reasons apparent to explain the correlation of variable 10 with variables 8, and more particularly, 17, the presence of variable 10 in Factor I for children will, for the present, be passed over.

Factor I, then, is a task specific factor, representing the third task, and comprises loadings from the three eye-movement measures taken on that task. Its composition is not typical of the composition of the remaining factors.

Factor II--Task Two, Tracklength and Refixation

Adults			Children		
2.	Tracklength, task 2	.896	2.	Tracklength, task 2	.976
7.	# refixations, task 2	.893	7.	# refixations, task 2	.933
			18.	Unscored frames, task 4	.541

Variables two and seven contribute most to the definition of Factor II for the two groups. There are two further factors, IV and V, which also represent an association between Tracklength and number of Refixations, either on the same task, or on tasks in which the stimulus characteristics are similar. Since the contribution of the two meas-

ures is consistently high on each of these factors, it appears that for the samples used in this study, there is a degree of redundancy between Tracklength and number of Refixations.

Variable 18 in the children's sample has a moderate loading on Factor II, but is complex with respect to its slightly higher loading on Factor III. Given that the low mean for variable 18 is derived from individual measures which have relatively high variance (see Table 24), its contribution to Factor II might have a chance rather than a psychological basis.

Factor II, then, is a task specific factor which represents the joint association between Tracklength and Refixation measures. It is paralleled by two further factors, with comparable composition, to be described later.

Factor III--Prolonged Search, Unscored Frames and Information Search Score

Adults		Children	
16. Unscored frames, task 2	-.841	16. Unscored Frames, task 2	-.863
12. ISS, task 2	.829	12. ISS, task 2	.725
		18. Unscored frames, task 4	-.579
		13. ISS, task 4	.475
		6. # refixations, task 1	-.449
		3. Tracklength, task 3	.410

Factor III represents, primarily, a combination of variables 16 and 12, these two measures being negatively related, and both being derived from performance on task two. This characterization of the factor is consistent with the pattern of loading on further factors, namely VI and VII, in which Unscored Frames and Information Search

Score combine, for specific kinds of tasks and stimuli, in their contribution to the composition of factors.

The moderate loading of variables 18 and 13 on Factor III for children raises an interesting point. The factor loadings provide a basis for inferring that for children, there is something common to performance on tasks two and four. It will be recalled that _Sam Slick_ picture stimuli were used in task two whereas _Wechsler_ Incomplete Pictures were used as stimuli in task four, so it is unlikely to be a similarity in the qualities of the stimuli which might account for loadings of task four variables on Factor III. Task two was a _prolonged_ search task on which eye-movements were recorded following a comparatively extended period of viewing the stimuli. Task four also involved the possibility of _prolonged_ search in that subjects were permitted a maximum of 30 seconds to view any one of the three stimuli, even though eye-movements were recorded for only the first three seconds of viewing any one of the stimuli. During the conduct of the experiment it was observed that children tended to take longer to solve the problems in task four than did adults. Thus, for the second and third stimuli presented on task four, the task assumed something of the nature of a _prolonged_ search task for the children.

Furthermore, by comparing the means of Information Search Score on tasks 1 and 2 (variables 11 and 12) on Table 24, for adults and for children, it can be seen that the effect of _prolonged_ search on the Information Search Score appears to be stronger for children than for adults. By comparing the means for variables 1 and 2, and for 6 and 7, it can be observed that the total amount of scanning is

reduced in the prolonged as compared with the non-directed search task. Accordingly, it appears that prolonged visual examination of stimuli is associated with an habituation-like effect upon eye movements. The loadings of variables 18 and 13 on Factor III for children then, may be interpreted as evidence that they, as distinct from the adults, have had their eye movements on task four influenced by an effect comparable to habituation. Such an interpretation is certainly consistent with the common knowledge that children are generally more distractable than adults.

The contributions of variables 6 and 3 to Factor III for children are not readily explicable, especially since their correlations with the remaining variables loading on Factor III are not high. It appears that the two variables might be associated with habituation effects, but both 6 and 3 are again complex variables, each having higher loadings on other factors, so their interpretation with respect to Factor III will not be pursued in the current study.

Factor III, it has been suggested, represents loadings from Unscored Frame and Information Search Score on prolonged search tasks in which, it is assumed, an habituation-like effect has had some influence. On the study of combined skin response, pupillary and eye-movement measures, it will be interesting to determine whether or not variables 12 or 16 are associated with other measures of habituation.

Factor IV--Task One, Tracklength and Number of Refixations

Adults			Children		
6.	# refixations, task 1	.872	1.	Tracklength, task 1	.931
1.	Tracklength, task 1	.858	6.	# refixations, task 1	.731
10.	# refixations, task 5	.636	13.	ISS, task 4	.522
5.	Tracklength, task 5	.424			

The variables contributing to Factor IV which are common to the two samples are variables 1 and 6. These are Tracklength and number of Refixations, respectively, and both measures are taken on the first task. If the highest loadings only are considered, then Factor IV appears to be comparable with Factors II and V in which Tracklength and Refixations from specific tasks combine to form the principal contribution to the factors.

For adults, Tracklength and Refixation measures from task five also load on Factor IV. Task one was a non-directed search task and task five was a directed search task, but both tasks involved stimulus pictures drawn from the same source. It appears possible, then, that the similarity in the stimulus materials themselves might account in part for loadings from two different tasks on the same factor.

The fact that the same variables, Tracklength and Refixations on task five, did not load on Factor IV for children must be accountable in terms of a differential response by adults and children to the distinct task conditions applying to the first and fifth tasks. Children's eye-movement behaviors on tasks one and five, it seems, differ on the two tasks as a function of the different instructions. The task conditions, or instructions, do not appear to have differentially influenced

the looking behavior of the adults. Indeed, it is reasonable to assume that for adults, failing receipt of task-oriented instructions for task one, subjects might have "self-instructed" themselves to look at the stimuli in a manner not dissimilar from that which was later employed on task five. By contrast, the children's looking behavior was under the more direct control of the different instructions applying to the two tasks.

The interpretation of the comparative difference in the composition of Factor IV for adults and children is supported by the fact that Information Search Score and Unscored Frame measures on tasks one and five load on factors in a similar fashion to the Tracklength and Refixation measures (compare Factors IV and VI for adults, and Factors IV, VI and VII for children). It should be noted, however, that if the interpretation is accepted, then Factor IV for adults is not directly comparable with Factor IV for children. For children the factor would represent loadings from a non-directed task. For adults the same factor would represent loadings from both a <u>self-directed</u> and a <u>directed</u> search task.

Variable 13, Information Search Score on task four, also loads on Factor IV for children. This variable is another complex variable for the children's sample. It may be recalled that variables 6 and 15, both of which appear on Factor IV, also have loadings on Factor III. The psychological basis for the association of variable 13 with Factor IV for children is not clear, and its contribution to the factor is noted but not examined further. A comment will be made about the

association between Information Search Score and Tracklength variables in the discussion concerning Factor VI.

The name proposed tentatively for Factor IV does not do justice to the discussion which has just been advanced. At this early stage of inquiry into the nature of the relationship among eye-movement measures, however, the descriptive title of any of the factors must be somewhat arbitrary and tentative. The title description has emphasized the similarities rather than accounted for the possible differences in the factor composition for the two groups.

Factor V--Task Four, Tracklength and Number of Refixations

Adults		Children	
9. # refixations, task 4	.872	4. Tracklength, task 4	.966
4. Tracklength, task 4	.860	9. # refixations, task 4	.821

Factor V is a further factor representing an association between Tracklength and Refixation measures as a function of task. It is comparable with Factors II and IV, and to some extent with Factor I, all of which involve contributions from Tracklength and Refixations to the composition of factors.

Factor VI--Task Five, Information Search Score and Unscored Frames

Adults		Children	
14. ISS, task 5	.887	19. Unscored frames, task 5	-.917
19. Unscored frames, task 5	-.728	14. ISS, task 5	.818
11. ISS, task 1	.646		
15. Unscored frames, task 1	-.641		
5. Tracklength, task 5	-.421		

Factor VI, with factor loadings from Information Search score and Unscored Frames is complementary to Factor IV on which there are loadings from Tracklength and Refixations. For adults on both factors, the respective measures from both tasks one and five load on the factors. For children, the respective measures from only one of the tasks load on the factors.

The interpretation advanced with respect to Factor IV appears relevant, in its intent, to Factor VI and will not be repeated here. These two factors do appear to provide evidence, however, that the factors appearing in this analysis of eye-movement measures are not only somewhat task specific, but are also sensitive to the specific qualities of the stimuli themselves, since tasks one and five have stimulus items drawn from the same item pool. The discussion at the conclusion of this chapter suggests further that there might be interesting differences in the looking behavior of adults and children with respect to different instructional conditions imposed upon the various tasks.

The loading of Tracklength from task five (variable 5) on the adult's Factor VI appears to stem from the correlation of variable 5 with variables 14 and 11, that is with the Information Search Score on tasks five and one (see Table 25). If one examines the composition of the several factors, there is a hint in the data that Tracklength measures generally are negatively related to Information Search Score and positively related to Unscored Frames. This relationship holds with respect to Factors I, II and VI. It is further supported by inspection

of the correlations reported in Tables 25 and 26 (examine correlations of variables 1 to 5 with variables 11 to 14 and with variables 15 to 19). An admittedly venturesome interpretation of this observation could be that those people who can identify the more significant elements of a stimulus display, (i.e., those having a high Information Search Score,) fix their gaze upon these more important elements at the expense of vague, random scanning over the entire display, (i.e., they have a comparatively low tracklength) or even beyond its bounds (low Unscored Frames).

As was the case with Factor IV, the title proposed for Factor VI is not only tentative, but does not represent the seeming meaningful differences in factor composition for adults and children. The factor primarily represents the characteristic association between Information Search Score and Unscored Frames as a function of task, assuming that for adults, tasks one and five are not phenomenologically greatly different.

Factor VII--Task Four, Unscored Frames and Information Search Score

Adults

18.	Unscored frames, task 4	-.806
13.	ISS, task 4	.754

Since the loadings on Factor VII represent different task variables for adults as compared with children, the factor will be described separately for the two groups. For both adults and children, however, Factor VII makes the smallest variance contribution of the

seven factors.

For adults, Factor VII is again stimulus and task specific and represents the now familiar inverse contribution of Unscored Frames and Information Search Score derived from the same task. It may be recalled that variables 13 and 18 for children loaded on the same factor, (III), as the equivalent measures taken on the prolonged search problem, task two.

Factor VII--Task One, Information Search Score and Unscored Frames

Children

11.	ISS, task 1	.780
15.	Unscored Frames, task 1	-.763

For children, Factor VII is again stimulus and task specific and is comparable to Factors III and VI in comprising both Information Search Score and Unscored Frame measures.

General Discussion of Factors

Correlations among the seven oblique factors are reported for adults in Table 29 and for children in Table 30 (page 129). Generally, the correlations between the factors are low, especially in the adult sample, thereby indicating that departure from orthogonality of the factors is not generally strong. The only pair of factors having a modest degree of correlation in both groups is Factors IV and VII, but it will be recalled that the composition of Factor VII for adults is in some respects different from that for children.

The obliquity among the children's factors is worth examining. It can be observed in Table 30 that correlations in the .20 to .40 range are associated with Factors I, II and V on one hand, and with Factors III, VI and VII on the other. Factors I, II and V are all defined, principally, by loadings from Tracklength and Refixation measures on the various tasks. Factors III, VI and VII all comprise loadings from the Unscored Frames and Information Search Score variables, again for different tasks. It appears in the solution for children, then, that relationships among the factors might be a function of the variables themselves such that obliquity exists between those factors which have loadings from the same kinds of dependent measures.

In the adults' sample a correlation of .225 relates Factors IV and V. Both of these factors have loadings from Tracklength and Refixation measures. The correlations between Factors I and VI (-.340) and IV and VII (-.209), however, depart from the configuration of relationship suggested in the solution for children.

Concerning the composition of the factors themselves, there is considerable similarity of factor loadings in the pattern matrices for the two groups, despite the difference in age. Most factors are identifiable as similar from one group to the other and tend to comprise rather narrow, even task specific group factors in which there is an association either of Tracklength and number of Refixation measures, or alternatively, measures of Informations Search Score and Unscored Frames, these latter two measures demonstrating a negative relationship.

The differences which do exist in factor loadings on particu-

lar factors are interesting, if not suggestive of possible differences in the visual investigatory behavior of the two groups. Factors IV and VI for adults both comprise measures taken from tasks one and five which differed in instructions given to subjects with respect to stimuli, but which did not differ greatly in the characteristics of the stimuli themselves. Since the same was not true for children, in that response measures from tasks one and five did not load on the same factors, it appears that children's looking behavior was influenced more differentially by the different instructions (directed search, and non-directed search) than was the looking behavior of adults.

A further difference between the groups appeared on Factor III. On this factor Information Search Score and Unscored Frames measures from both tasks two and four loaded on this factor for children, but the same measures from task two only contributed to the factor composition for adults. The stimulus figures in task two, it will be recalled, were sampled from the same pool of stimulus figures as was used for tasks one and five. Tracklength, Refixation and Information Search Score measures, however, were markedly lower in mean value for both groups on task two, the prolonged search task, than on tasks one and five. Conversely, the mean value for Unscored Frames was higher on task two than on either of the other tasks. It has been suggested that the comparative difference in looking behavior with respect to tasks one and two might be indicative of an habituation effect influencing visual search responses on the second task. The association of some task four variables with some task two variables on Factor III for children might then indicate that children are more open than adults

to an habituation-like effect upon visual investigatory responses. This conclusion, it has been noted, is consistent with the widely held notion that children can sustain attentional behaviors less adequately than can adults.

Conclusions

No hypotheses were advanced in relation to this study of eye-movement measures. In terms of the orientation reaction, however, the analysis may become more meaningful in relation to the fourth study in which selected eye-movement measures are related to measures of the galvanic skin response and to pupillary responses. At this point, nevertheless, it seems unlikely that the eye-movement measures employed herein can be indicative of either phasic or tonic aspects of the orientation reaction. Observations of eye movements were made over the first three seconds since it is roughly within this period that at least phasic aspects of the reaction are normally manifest. But since factor loadings represent task specific measures in the main, orienting behavior, which would not be expected to be strongly task specific, does not appear to be reflected in the response measures taken in this study.

There is evidence in the data, however, of a possible effect upon visual search behavior which might be similar to habituation of the orientation reaction. An habituation effect can be expected to be manifest through a progressive weakening of a response under conditions of repeated or prolonged exposure and just such an effect has been

noted in the eye-movement data. It would be an unwarranted conclusion to propose that task two responses do in fact represent habituation of an orienting response, but an investigation of possible relationships between Factor III and genuine habituation of orienting responses might, ultimately, be worth undertaking.

CHAPTER VIII

COMBINED GALVANIC SKIN RESPONSE, PUPILLARY AND EYE-MOVEMENT STUDY--RESULTS AND DISCUSSION

Selection of Variables

Selection of variables for inclusion in the combined study was determined on either one, or both of two bases. Firstly, response measures selected were to represent the variety of variables which were used in the three previous studies. That is to say, for example, that there must be some representation of amplitude, conductance change and habituation where the galvanic skin response measures were concerned. Secondly, measures were selected which had relatively high loadings on significant factors for both the adult and children's groups. Factors judged as significant were those which appeared to represent aspects of the orientation reaction, or in the eye-movement study, those factors which represented the range of specific measures used.

Five measures were selected from the galvanic skin response study. The amplitude measures from tasks 4 (auditory anagrams) and 6 (five signal tone stimuli) were included as representative of the phasic response. The two conductance change measures, one from each of the two anagram tasks, were selected as representative of a possible tonic response. In the Galvanic skin response study these two measures had loaded on the same factor for children, but for adults they loaded on

separate factors. Number of trials to habituation was taken as representative of the habituation factor.

Five measures were also selected from the pupillary variables. Here the amplitude measures for tasks 1 (non-signal tone stimuli) and 6 (signal tone stimuli) were chosen. These two measures had loaded on Factor III in the nine variable pupillary response study. Two base change measures, one from each of the anagram tasks were also included in further pursuit of the possibility that they might represent something like a tonic orienting response. The base change measures had loaded on one factor for adults, but on two separate factors for children in the nine variable pupillary response study. The fifth variable, number of trials to habituation, was again selected as representative of the habituation factor.

The selection of eye-movement measures was rather more intuitive than was the case for the other two sets of measures. A fundamental concern was to include variables representative of the four different kinds of response measure used in the eye-movement study. But since specific kinds of measures, tracklength for instance, tended to load on separate factors as a function of task, measures were selected from those factors making the greater variance contribution.

Accordingly, Tracklength and number of Refixations for task 1, (<u>non-directed search</u> on Sam Slick pictures) were selected from Factor IV. This factor made the second highest variance contribution for adults and the fourth highest contribution for children. Information Search Score and number of Unscored Frames for task 2 (<u>prolonged search task</u> on Sam Slick pictures) were included to investigate their possible

association with the psychophysiological measures of habituation. In the discussion of results in the eye-movement study, interest was expressed in the possibility that Information Search Score and Unscored Frames on task 2 might reflect an habituation effect. The equivalent pair of measures from task 5 (directed search with Sam Slick pictures) was included to permit investigation of Information Search Score and Unscored Frames where habituation influences were not suspected. These two variables had loaded on Factor VI which made the highest variance contribution for adults, but the sixth greatest contribution for children. Thus, a total of six eye-movement measures was included in the combined study.

Description of Analyses

Initially, principal component analyses were carried out as described in the previous studies. The decision as to the number of factors to be extracted was guided, as in the previous studies, by interpretability, the aim to achieve as great a simplification of the variables as possible, and the magnitude of the communalities. Simplification, of course, was enhanced by the extraction of fewer rather than more factors, but since some variables failed to contribute to the variance when fewer than six factors were extracted, the first six factors were extracted for both groups.

Once again, the unrotated factors were subjected to oblique transformation using Hakstian's generalization of the Harris-Kaiser method, with many values of p and w being tried. The solution finally

chosen, on the grounds of simple structure, employed $p = 0.0$ and $w = 6.0$ for both adults and children. These values indicate that the solutions were fairly oblique with the variance being more evenly distributed among factors than would be the case in a varimax solution.

For convenience, means and standard deviations for the sixteen variables used in the combined analysis are reported in Table 31. This table merely assembles information already presented in previous tables with the exception that new identification numbers have been assigned to the variables. Intercorrelations among the sixteen variables are reported in Table 32 for adults and in Table 33 for children. The new information presented in Tables 32 and 33 comprises the intercorrelations among measures taken from the three response modes. Generally, these intercorrelations are very low, but there are a few values in the 0.3 to 0.5 range.

Tables 34 and 35 present the Harris-Kaiser oblique primary pattern matrices for $p = 0.0$, $w = 6.0$. Communalities recorded in these tables are abstracted from the preliminary orthogonal solutions. The correlations among the six oblique factors are presented in Table 36 for adults and in Table 37 for children.

As in the three previous studies, a rotation of one factor matrix to achieve maximum overlap with the other introduced an unacceptable level of complexity into the rotated solution. Such a transformation did produce greater comparability in factor loadings (in a least squares sense) between the two groups, but the marked increase in complexity in the rotated matrix suggests that the adults and chil-

Table 31

Means and Standard Deviations for Adults and Children

on Sixteen Selected Variables

Measure	Adults Mean	Adults S.D.	Children Mean	Children S.D.
Galvanic skin response:				
1. Amplitude--four auditory anagrams	-0.022	0.018	-0.019	0.013
2. Amplitude--imagined button press, tones	-0.017	0.010	-0.021	0.015
3. Conductance change--audit. anagrams	-0.009	0.037	-0.023	0.057
4. Conductance change--visual anagrams	-0.021	0.052	-0.009	0.019
5. Habituation--number of trials	11.625	8.910	13.081	12.904
Pupillary response:				
6. Habituation--number of trials	23.525	11.914	30.649	17.884
7. Amplitude--five pure tones	3.427	1.480	3.994	1.454
8. Base change--audit. anagrams	5.897	3.448	5.968	2.924
9. Base change--visual anagrams	3.326	2.999	2.433	3.117
10. Amplitude--imagined button press, tones	4.311	1.580	4.994	2.222
Eye Movements:				
11. Trk.[1]--task 1 non-directed search, pictures	12.749	3.984	12.486	2.868
12. Nrfix.[2]--task 1 non-directed search, pictures	11.183	2.883	12.018	2.160
13. ISS[3]--task 2 prolonged search, pictures	96.551	20.385	80.577	22.993
14. ISS--task 5 directed search, recall pictures	109.244	9.517	109.397	11.398
15. Usf.[4]--task 2 prolonged search, pictures	3.125	3.428	6.081	5.960
16. Usf.--task 5 directed search, recall pictures	0.846	0.844	1.113	1.255

1. Trk.--Tracklength
2. Nrfix.--Number of refixations
3. ISS--Information search score
4. Usf.--Unscored frames

Table 32

Intercorrelations for Sixteen Selected Variables for Adults (N = 40)*

Galvanic Skin Response, Pupillary Response, Eye Movements

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	--															
2	47	--														
3	28	20	--													
4	05	06	02	--												
5	-02	-09	05	22	--											
6	-37	-12	-29	01	-12	--										
7	-12	-01	01	06	40	13	--									
8	12	00	-06	24	23	-17	14	--								
9	25	12	-04	05	-16	-16	-13	28	--							
10	02	-15	19	-03	23	-05	39	35	15	--						
11	29	24	08	02	-18	-24	-34	08	04	-13	--					
12	30	22	09	21	03	-19	-22	09	05	-06	82	--				
13	07	-04	-17	09	04	21	-06	02	01	-01	-15	-03	--			
14	-11	-01	-06	-17	20	13	11	22	15	08	-13	-06	-05	--		
15	-27	04	07	04	00	06	08	-02	-24	02	07	-06	-56	-02	--	
16	-17	-14	-05	-03	-20	10	20	-21	-50	-04	-02	-05	-12	-53	23	--

* Decimals have been omitted.

Table 33

Intercorrelations for Sixteen Selected Variables for Children (N = 37)*

Galvanic Skin Response, Pupillary Response, Eye Movements

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	--															
2	56	--														
3	06	07	--													
4	25	29	42	--												
5	-01	13	-09	-16	--											
6	07	19	-04	23	05	--										
7	27	17	-11	13	-15	32	--									
8	-04	-03	-30	-02	-26	-19	02	--								
9	30	22	06	-10	06	-08	16	24	--							
10	38	38	-20	17	-02	31	52	40	16	--						
11	02	07	09	27	-03	03	17	32	00	21	--					
12	01	-04	03	22	06	09	22	39	21	28	67	--				
13	-11	13	07	-11	13	06	-03	01	-14	03	-02	-15	--			
14	24	34	06	13	18	16	28	-09	08	03	-02	16	39	--		
15	21	-09	04	28	00	-11	04	24	10	05	26	39	-69	-27	--	
16	-12	-16	-15	03	13	27	02	-08	-21	17	05	-09	-22	-60	14	--

* Decimals have been omitted.

Table 34

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.0, $\underline{w}$ = 6.0) for Adults (N = 40)

Sixteen Selected Variables*

Variable/Factor	I	II	III	IV	V	VI	h^2
1	108	-728	288	-006	-063	-044	704
2	148	-548	009	174	017	252	424
3	-195	-764	-169	-057	165	067	571
4	558	174	207	-135	430	-175	487
5	125	-090	062	288	871	-090	771
6	-048	610	104	078	064	227	480
7	-228	-036	-064	-116	662	-211	641
8	239	148	-022	064	-002	-808	714
9	-060	-111	141	318	-441	-528	668
10	-215	-139	-072	-141	256	-688	648
11	793	-090	-173	-019	-215	021	815
12	895	-055	001	021	052	028	818
13	-001	148	884	-060	092	065	790
14	-081	167	-188	873	127	032	784
15	096	123	-847	-041	081	025	765
16	-027	097	-129	-851	054	052	828
Variance contribution	2.01	1.96	1.78	1.77	1.76	1.63	10.91

*Decimals have been omitted.

Table 35

Oblique Primary Pattern Matrix ($\underline{p}$ = 0.0, $\underline{w}$ = 6.0) for children (N = 37)

Sixteen Selected Variables*

Variable/Factor	I	II	III	IV	V	VI	h^2
1	-206	-775	221	-212	130	039	739
2	124	-633	278	-107	135	152	632
3	037	-044	-301	032	771	039	673
4	-114	-026	213	166	774	-014	752
5	033	-224	-196	364	-382	889	909
6	125	184	701	003	166	327	636
7	093	-169	637	041	015	-137	526
8	-016	-003	101	379	-345	-617	772
9	-150	-693	-160	075	-282	-122	545
10	-015	-200	763	102	-184	-152	779
11	013	177	100	820	153	-024	732
12	-023	-018	010	909	004	-016	849
13	879	179	082	055	-044	001	759
14	672	-419	-059	219	112	110	753
15	-783	-210	-140	313	112	012	813
16	-500	462	496	-100	-118	345	803
Variance contribution	2.21	2.13	2.10	2.04	1.70	1.49	11.67

*Decimals have been omitted.

Table 36

Correlations Among the Six Oblique Factors:

Sixteen Selected Variables--Adults*

Factors	I	II	III	IV	V	VI
I	---					
II	-296	---				
III	017	-012	---			
IV	009	-079	134	---		
V	-185	102	-070	-024	---	
VI	-014	112	-064	-229	-150	---

*Decimals have been omitted

Table 37

Correlations Among the Six Oblique Factors:

Sixteen Selected Variables---Children*

Factors	I	II	III	IV	V	VI
I	---					
II	-106	---				
III	-029	-215	---			
IV	-141	-157	191	---		
V	003	-133	055	072	---	
VI	099	064	-004	-201	065	---

*Decimals have been omitted

dren appear to come from relatively distinct populations.

Whereas a substantial similarity in factor loadings between adults and children was characteristic of the three previous studies, the same degree of similarity between the solutions for the two groups was not observed in the analysis of combined measures. At first glance this disparity between the solutions for adults and children appears inconsistent with the findings in the previous studies. It should be recalled, however, that in each of the studies some variables showed complexity in their factor loadings. When the measures from the three response modes are combined, as in the current study, this complexity is compounded and thereby reduces the similarity between the solutions for the two groups.

It should be added, however, that the associations among particular variables in any one response mode which were demonstrated in the previous studies have been preserved in the current analysis with rare exceptions. For instance, the two conductance change measures which loaded on one factor for children but on separate factors for adults in the nine variable galvanic skin response study had the same pattern of loadings for the two groups in the present analysis of the combined measures.

Since the pattern matrices of adults and children have become less similar in this analysis of combined measures, the format for reporting results which was adopted in the three previous chapters will be modified. Rather than presenting the description of factor loadings for children concurrently with that for adults, the two groups

will be described separately. Accordingly, a description of factors for adults will be presented first, followed by the description for children. For each group, factors will be considered in the order of their magnitude of variance contribution without consideration of the order of emergence of factors in the other group. Then a comparison between adults and children will be considered towards the end of the chapter.

Description and Discussion of Factors for Adults

Factor I--Tracklength and Number of Refixations

Adults

12.	# refixations, task 1 non-directed search	.895
11.	Tracklength, task 1 non-directed search	.793
4.	Conductance change, visual anagrams	.558

The measures with the highest loadings defining Factor I are both from the eye-movement study in which they were also associated. The conductance change measure of the galvanic skin response to visual anagram problems also has a moderate loading on Factor I. It is perhaps noteworthy that conductance change from the visual, as distinct from the auditory anagrams, should load on what is principally an eye-movement factor. Because of the inversion in skin response measures brought about by the logarithmic transformation, the loadings on Factor I reveal that small, rather than large, changes in actual conductance are associated with many refixations and high tracklength.

Table 36 reveals that there is a correlation of -0.296 between

Factor I and Factor II which largely comprises loadings of galvanic skin response measures. In general then, Factor I appears to be principally an eye-movement factor which has a negative relationship with degree of arousal as represented by the skin response. Quite tentatively, it appears that the lower the level of physiological arousal, the more widespread are the points of eye fixation with respect to visual stimuli. The loadings on Factor I provide no evidence that tracklength and refixation measures may be simply or directly linked with phasic, tonic or habituation aspects of the orientation reaction.

Factor II-Galvanic skin response arousal

Adults

3.	Conductance change, auditory anagrams	-.764
1.	GSR amplitude, auditory anagrams	-.728
6.	Pupillary habituation, number of trials	.610
2.	GSR amplitude, imagined button press	-.548

The loadings of the galvanic skin response measures on Factor II are similar to the loadings on Factor I in the nine variable galvanic skin response study. In the skin response study all possible amplitude measures loaded together along with a minor contribution from conductance change on auditory anagrams.

An interesting observation about Factor II is that high galvanic skin response changes appear to be related to slow rates of habituation of the pupillary response. The correlations (Table 32) which relate variable 6, pupillary habituation, with variables 1, 2 and 3 are not high, but they are consistent. It seems possible that

an interrelation between the two response modes is being reflected in Factor II.

The loading of pupillary habituation on a factor independently of the remaining pupillary measures is consistent with the outcome in the study of pupillary variables alone.

Lastly with respect to Factor II, it should be noted that amplitude measures, or any other type of measure, from one response class have not become associated with equivalent measures from another response class. The issue of possible relationships among the various response classes will be addressed more generally at a later point in the discussion.

Factor III--Information Search Score and Unscored Frames, Prolonged Search

Adults

13.	Information Search Score, task 2 prolonged search	.884
15.	Unscored Frames, task 2 prolonged search	-.847

Factor III appears directly comparable with Factor III in the eye-movement study. In the current study, Factor III has negligible correlation with all other factors, the largest being with Factor IV which is 0.134. Factor IV is defined by loadings from Information Search Score and Unscored Frames on task 5, a directed search task.

In the eye-movement study reported in Chapter VII it had been proposed that variables 13 and 15 listed above might be related

to physiological measures of habituation. Such has not proved to be the case. Indeed, one of the most notable features of Factor III is its marked failure to associate the particular eye-movement measures loading on the factor with any of the physiological measures.

Factor IV--Information Search Score and Unscored Frames, Directed Search

Adults

14.	Information Search Score, task 5 directed search	.873
16.	Unscored Frames, task 5 directed search	-.851

Factor IV is another eye-movement factor. It represents the now familiar association between Information Search Score and Unscored Frames on the same task, where these two measures are inversely related. Factor IV has a reasonably high correlation (r = -.229) with Factor VI in this oblique solution. Factor VI comprises three pupillary measures, but the relationship between Factors IV and VI is possibly occasioned largely by the correlation of -0.50 between pupillary base change on visual anagrams and number of unscored frames on task 5, a directed search task. As with Factor I, this correlation between factors again provides evidence of a weak relationship between degree of physiological arousal and eye-movement responses.

Factor V--Galvanic Skin Response Habituation

Adults

5.	GSR Habituation, number of trials	.871
7.	Pupillary amplitude, five pure tones	.662
9.	Base change, visual anagrams	-.441
4.	Conductance change, visual anagrams	.430

The variable with the highest loading on Factor V is the measure of rate of galvanic skin response habituation. A rather lesser contribution is made by the amplitude of pupillary response to non-signal tone stimuli. The remaining variables which contribute to Factor V, variables 9 and 4, are both complex and have higher loadings on other factors. The correlation of variables 9 and 4 with the habituation and pupillary amplitude measures loading on this factor are very slight, so the contribution of variables 9 and 4 to Factor V will be ignored.

As in the galvanic skin response study, habituation of the skin response loads on a factor independently of the remaining galvanic skin response measures. In the current analysis, the habituation measure is associated with one of the two available pupillary amplitude measures. In the preliminary pupillary study, the two pupillary amplitude measures selected for the combined analysis had loaded on one and the same factor. In this combined analysis they have become dissociated. It is worth noting that the correlation between variables 5 and 7 which both load on Factor V is 0.40, but the magnitude of relationship is not matched in the analysis for children. It does appear that those adults who were slower to habituate the galvanic skin response also gave higher pupillary response amplitude to the pure tones but in the light of the indeterminacies just mentioned, the contribution of only the highest contributing variable has been acknowledged in the label of Factor V.

Factor VI--Pupillary Response to Auditory Signal Stimuli

Adults

8.	Base change, auditory anagrams	-.808
10.	Pupillary amplitude, imagined button press	-.688
9.	Base change, visual anagrams	-.528

The factor making the least contribution to the variance in the combined analysis has loadings from a combination of pupillary measures. The variables with the two highest loadings were associated on the one factor in the analysis of pupillary measures alone, but the third variable did not load on the same factor in that study.

Factor VI, then, appears as a pupillary factor which further disconfirms the possibility of somewhat regular relationships existing between pupillary responses and equivalent galvanic skin responses. The factor is correlated with Factor IV as previously noted.

Summary of Combined Analysis for Adults

The evidence of the current study fails to support hypothesis 3.1 which proposed that a minimum of three factors would emerge in the combined analysis, these three factors being identifiable as phasic, tonic and habituation aspects of the orientation reaction, and each factor having loadings from the three response domains. Rather, the evidence of the current study suggests that variables within any one response class (that is, pupillary responses as compared with eye movements) tend to load together. Second, the associations which were revealed by factor loadings in the three separate preliminary

studies have not been seriously disturbed when a more diverse array of response measures are factor analysed together. Third, while eye-movement factors show almost no loadings from the physiological responses, the obliquity which exists among factors is between factors representing eye-movement measures on one hand, and factors representing physiological response measures on the other. It thus appears that some functional relationship might exist between the eye-movement and physiological response modes. In brief, the evidence points towards multidimensionality rather than unidimensionality in the relationship among the responses analyzed in the study.

Description and Discussion of Factors for Children

Factor I--Information Search Score and Unscored Frames

Children

13.	Information Search Score, task 2 prolonged search	.879
15.	Unscored Frames, task 2 prolonged search	-.783
14.	Information Search Score, task 5 directed search	.672
16.	Unscored Frames, task 5 directed search	-.500

Factor I is an eye-movement factor having loadings from all information search score and unscored frames measures included in the analysis. In the study of eye movements alone, variables 13 and 15 loaded together but on a different factor from variables 14 and 16. Nevertheless, there was quite a high correlation between the factors on which these pairs of measures loaded.

The point of greatest note concerning Factor I is that it has no loadings from either the skin response or the pupillary response

measures. Nor is the factor highly correlated with any other factor having pupillary response or galvanic skin response loadings. It had been proposed in the analysis of eye movements that task 2 measures might relate to rate of habituation measures, but for the data in the current study, such is not the case.

Factor II--Distractability - Attentiveness 'A'

Children

1.	GSR amplitude, auditory anagrams	-.775
9.	Base change, visual anagrams	-.693
2.	GSR amplitude, imagined button press	-.633
16.	Unscored Frames, task 5 directed search	.462
14.	Information Search Score, task 5 directed search	-.419

The wide range of seemingly disparate measures loading on Factor II raises interesting questions and possibilities but challenges description in terms of a brief integrating label. Increasingly the data point towards a dimensionality in arousal, but it could be misleading to venture names for such dimensions at this stage.

Variables 1 and 2, the two measures of galvanic skin response amplitude, loaded together with further amplitude measures in the earlier skin response study, where the factor was described as representing the phasic orienting response. In Factor II above, the two amplitude measures are associated with the pupillary base change measure for visual anagrams, and in terms of real changes in arousal, the relationship is actually negative since the logarithmic transformation of skin response measures reversed the large and small changes in conductance. The data suggest that for the subjects in the study, large galvanic skin response

amplitude may have been associated with relatively small pupillary dilation changes in response to the presentation and solving of visual anagrams. But to add to the psychological complexity of Factor II, two eye-movement measures also load on this factor. They are Unscored Frames and Information Search Score from the directed search task.

The actual degree of intercorrelation among some of the variables contributing to Factor II is not particularly high, but given the generally low level of correlation expected among physiological and psycho-motor measures, and confirmed in the current study, the consistency of relationship among the variables contributing to Factor II might well represent something stronger than chance association. For convenience, the correlations are summarized as follows.

	1	2	9	14	16
1	--				
2	56	--			
9	30	22	--		
14	24	34	08	--	
16	-12	-16	-21	-60	--

In comparison to the near zero correlations which describe the relationship among many of the variables in the study, the set of correlations reported above stands in reasonable and consistent contrast.

If the loadings on Factor II are tentatively taken as they stand, then the composition of the factor appears to be describing behavior as follows. Those children who looked at the less informative parts of the pictures (low Information Search Score) were also distracted more by external stimuli (high Unscored Frames) and gave larger galvanic skin responses (negative GSR amplitude) when isolated tone stimuli were presented. These same children also gave minimal pupil-

lary dilation while responding to visual anagram problems (low pupillary base change). Expressed in this way, the factor does not appear unreasonable. Indeed it appears to be presenting a credible though limited picture of a distractable child. The only variable within the study possibly related to distractable behavior which Factor II does not include is rate of habituation. Factor II, however, has a correlation of -.215 with Factor III on which there is a loading from pupillary habituation.

In brief, Factor II which makes the second highest variance contribution and thereby warrants more serious consideration than some of the later emerging factors, might represent a bipolar dimension representing an aspect of distractability versus attentiveness. Further discussion of the factor will be reserved for the concluding section of this chapter.

Factor III--Distractability - Attentiveness 'B'

Children

10.	Pupillary amplitude, imagined button press	.763
6.	Pupillary habituation, number of trials	.701
7.	Pupillary amplitude, five pure tones	.637
16.	Unscored Frames, task 5 directed search	.496

In Factor III the two pupillary amplitude measures are related with the number of Unscored Frames on task 5. The direction of association between the amplitude and unscored frame variables is consistent with that demonstrated in the previous factor where large amplitude measures, no doubt interpretable as large orienting responses,

are associated with a high number of unscored frames. The correlation between Factors II and III has already been noted and Factor III appears functionally parallel with Factor II but determined by pupillary measures in comparison to Factor II which was more determined by galvanic skin response measures.

In the study of pupillary variables alone, measures 7 and 10, the two amplitude measures, also loaded on the same factor but not, as in the current study, with any contribution from pupillary habituation on the same factor. Once again it appears that when more diversity is introduced among the variables in the form of measures derived from different response classes, then the interrelationship among aspects of the orientation reaction which Sokolov proposes becomes more evident.

Drawing together the variables which contribute to Factor III, the following behavioral description may be advanced. Children who most frequently glanced away from the stimuli presented in eye-movement task 5 (high unscored frames) also gave the strongest dilation when provided with either signal or non-signal simple tone stimuli (high pupillary amplitude). These children also took a comparatively greater number of trials to reach habituation of the pupillary response. Summarized in these substantially operational terms, the factor appears quite similar to Factor II with which it is correlated.

Factor IV--Number of Refixations and Tracklength

Children

12.	Number of Refixations, task 1 non-directed search	.909
11.	Tracklength, task 1 non-directed search	.820

Factor IV is defined by the two remaining eye-movement variables, number of Refixations and Tracklength on task 1, the non-directed search task. The close relationship between tracklength and refixations was clearly demonstrated in the eye-movement study in which variables 11 and 12 were also associated on the same factor.

In the combined analysis, the principal point about Factor IV is that it has no loadings from the remaining physiological measures. This factor, however, has a correlation of -0.201 with Factor VI which has a positive loading from galvanic skin response habituation and a negative loading from pupillary base change on auditory anagrams. Hence, it appears that those children who made repeated fixations on different points of the visual stimulus, thereby recording a relatively high length of track between the successive fixations, tended to be the same children who habituated the galvanic skin response relatively quickly and perhaps also gave large pupillary dilation responses while attempting to solve auditory anagrams. It is to be noted that the relationship between the eye-movement measures loading on Factor IV and the physiological measures just mentioned comes only indirectly through a modest obliquity between factors.

Factor V--Tonic galvanic skin response

Children

4.	Conductance change, visual anagrams	.774
3.	Conductance change, auditory anagrams	.771

The two variables listed above loaded together in the galvanic skin response study. The current study provides no basis for providing a different interpretation of the factor from that presented in the earlier study. Factor V has negligible obliquity with other factors in the analysis.

Factor VI--Habituation of the Galvanic Skin Response

Children

5.	GSR habituation, number of trials	.889
8.	Base change, auditory anagrams	-.617

Factor VI makes the smallest variance contribution of all the factors in the solution for children, and hence warrants least confidence in its structure. Variables 5 and 8, the only two variables loading on the factor have a correlation of -0.26. Hence, there is not a strong basis for confidence that Factor VI is more than a specific factor representing habituation of the galvanic skin response. The association of habituation with pupillary base change could well be a chance relationship.

Summary of Combined Analysis for Children

As was true of the analysis of measures for adults, the factor

loadings for children fail to provide support for hypothesis 3.1 which proposed that there would be a minimum of three factors identifiable, respectively, as phasic, tonic and habituation aspects of the orientation reaction. Furthermore, while some of the factors in the children's study are comparable with factors in the study of adult responses, the overall detail in association between specific response measures is generally different from one group to the other. On these grounds, hypothesis 3.2 which proposed a similarity between factors for adults and children must also be rejected.

It has been observed, that in general, response measures within any one response mode normally load on factors according to the outcomes in the preliminary analyses reported in chapters V, VI and VII. In other words, the analysis of a more diverse array of measures did not generally lead to the collapse of factors which had already been identified. At the same time, relationships among the three response modes have also been observed, most directly with respect to galvanic skin response and dilation responses, and to a lesser extent with eye-movement measures.

Given the generally low level of intercorrelation among the measures, it is not immediately evident whether or not the factor loadings stem from real or chance relationships, though this comment is most relevant to those factors making the least contribution to the common variance and to those variables having the lowest loadings on specific factors. At the same time, there has been a substantial stability among the associations of particular groups of variables

whether these are analysed within particular response modes as in the preliminary studies, or within a combined analysis as reported in this chapter.

In brief, the analysis of children's response measures supports the general findings of the analysis of adult measures. Specifically, there is no direct evidence of a more or less unidimensional orientation reaction having phasic tonic and habituation components, and occuring independently of the stimulus, task and age variables applying during the gathering of response data. On the contrary, the evidence strongly favors the notion that the three response classes examined in the study have complex relations among them and that multidimensionality, rather than unidimensionality, characterizes arousal change within different psychophysiological systems. Furthermore, these relationships probably differ as a function of age.

Conclusions

A tentative approach to integration of the results of the three preliminary studies and this final combined analysis will be presented in the final chapter. For the present, brief discussion will be directed to the observations which may be made concerning the analysis of the combined measures.

The construct of an orientation reaction comprising reliable responses to signal and non-signal stimuli, and occuring within a range of response modes finds little support in the observations reported in the current chapter. This is not to say that something like

orientation behavior, as described by Sokolov and others, does not occur, but the evidence presented does not fit with the simpler views of the orientation reaction which are commonly presented. The changes in arousal which constitute the reaction appear to be complexly related from one system to another and in many cases seem quite sensitive to the situational factors, both inside and outside of the person, which are present at the time of experimentally managed stimulus change. More particularly for the children than for the adults, factors have emerged which can be not unreasonably interpreted as representing bipolar dimensions of distractability-attentiveness. Both Factors II and III for children seemed to represent such a possibility. But the fact that there were two such factors is important in itself. In the discussion of these factors some mention was made of the fact that a preponderance of pupillary measures contributed to one factor whereas there were galvanic skin response measures loading on the other factor. Perhaps equally relevant is the observation that for Factor II, factor loadings represented responses more particularly to complex stimuli, where simpler stimuli gave rise to the response measures loading on Factor III.

The differences between the pattern of loadings for adults and children also is worth noting. It has been mentioned that the somewhat minor differences between the factor solutions for adults and children which were observed in the preliminary studies were inevitably compounded when a selection of the same variables were collectively analysed. But this observation does not escape the fact that the pat-

tern of loadings for the two groups in the combined analyses reveals some distinct differences. Often enough the low correlations holding among physiological and psycho-motor responses are viewed as a nuisance and taken as evidence of error, noise and unreliability. But perhaps the commonly discouraging lack of relationship among variables should not be viewed as anything but a difficulty for the inadequate assumptions, constructs and theories which we employ in looking at such data.

The Sokolovian notion of the Orientation Reaction is reasonably consistent with those western views of activation which conceive the arousal construct as representative of a unidimensional continuum of change. The factor analyses of the combined measures does not seem to be consistent with such a view. Rather, it supports the propositions of Berlyne (1967), Lacey (1967), Taylor and Epstein (1967) and others who propose that a more adequate conceptual model for thinking of activation and arousal might employ a number of dimensions which might have quite complex relations among them.

CHAPTER IX

SUMMARY, INTEGRATION AND CONCLUSION

Summary of Results

A series of four studies was designed to contribute to the investigation of the construct of individual susceptibility to phasic, tonic and habituation aspects of the orientation reaction. The purpose of each study was to examine how sets of physiological and eye-movement measures are associated on specific factors and to determine whether or not the structure of specific factors could be interpreted as representing phasic, tonic and habituation aspects of the orientation reaction. Further, within each study factor loadings for two independent groups, one of adults and the other of children, were compared to identify similarities and differences in the factorial structure. Hypotheses were advanced within three of the four studies. In general terms these hypotheses proposed that:

1. specific response measures would load on a minimum of three separate factors, these factors being interpretable as phasic, tonic and habituation components of the orientation reaction;
2. the same three factors would emerge from the analyses in identifiable form for both adults and children.

Subjects were presented with a series of non-signal and signal, auditory and visual stimuli within six task conditions during

which both galvanic skin response and pupillary dilation response measures were taken concurrently. A further set of visual stimuli were presented within five further tasks which collectively employed three distinguishable instructional sets. Eye movements were recorded throughout these five tasks.

Results have been reported within the framework of four studies. In the first, relationships among galvanic skin response measures were examined. In the second and third, a similar examination of pupillary and eye-movement responses respectively was made. In the final study response measures from the three previous studies were selected on the basis of their contribution to representative factors and submitted to a further factor analysis. Descriptions of factors were presented within each study.

In all studies a preliminary series of principal component solutions and varimax transformations, each extracting one less factor than the previous solution, was undertaken prior to making a decision concerning the number of factors to be extracted and examined. This step was followed by a series of oblique solutions in which the angle of obliquity and relative variance contribution among the factors were systematically varied. The solution finally chosen within each study, whether orthogonal or oblique, was selected principally on the grounds of simple structure. In all studies a rotation of the factor matrix for one group to achieve maximum overlap with the matrix for the other group was tried. In all studies these factor matches were rejected on the grounds that the minimal improvement in comparability

of factor loadings between groups that occurred was offset by a serious increase in the complexity of factor loadings.

In the nine variable galvanic skin respone study three factors were identified in each of the groups. The variables loading on the first factor were principally from the amplitude measures of the galvanic skin response, these having been taken under a variety of stimulus and task conditions. The factor was tentatively identified as representative of a phasic component of the orienting response. The second factor had high loadings only from the two related measures of rate of habituation and was therefore interpreted as representing rate of habituation of the electrodermal orienting response. The third factor differed a little in its composition between adults and children. Its loadings came from conductance change measures and the factor was interpreted as possibly representative of the tonic component of the orienting response.

Considerable similarity in factor composition between adults and children was noted for the first two factors, but comparability was less evident in the composition of Factor III. The results of this first study were interpreted as offering substantial support for the two hypotheses, one concerning the identification of factors representative of the phases of the orienting response, and the other concerning comparability in factor composition between adults and children. The orthogonal solution was interpreted as suggestive of more dissociation between phasic, tonic and habituation phases of the orienting response than appears to be indicated by Sokolov's accounts

of orientation behavior.

In the nine variable pupillary response study correlations among the measures were noted as being generally lower than in the galvanic skin response study with comparatively fewer correlations reaching statistical significance. Four factors were extracted for both adults and children but only three of the four adult factors were interpreted as group (as distinct from specific) factors.

One factor for each group of subjects had loadings from habituation measures only. The remaining factors for both adults and children were most commonly determined by loadings from both amplitude and base change measures. It had been hypothesized that if function generality applied to the orientation construct, then most amplitude measures might load together on one factor while the base change measures alone would load on a different factor. Since the factor loadings were contrary to this prediction the observations were interpreted as failing to support directly Sokolov's account of the orientation reaction in which distinct phasic and tonic aspects could be differentiated among pupillary responses.

Rather, the observations were interpreted as indicating that the functioning of the pupillary response was sensitive to the variety of stimulus and task conditions which had been presented. Specifically, dissociation, or lack of broad patterns of correlation, among the response measures appeared to be determined, at least in part, by the instructional set and expected task difficulty. In the case of the children only, there was evidence that mode of sensory

stimulation might have contributed to dissociation, since responses to visual stimuli alone loaded on Factor IV. An equally tenable alternative interpretation of this observation is that Factor IV loadings were determined by the particular difficulty of the visual task for children.

Tentatively, it was proposed that pupillary orienting responses might be dimensionalized in terms of degree of attentiveness, where such attentiveness is determined by the relative simplicity or complexity of stimulus and task conditions. The differences in the factor matrices for adults and children were viewed as suggestive of age-related differences in response dissociation.

In the eye-movement study, seven factors were extracted for both groups. In general, the contribution of variables to factors was comparable between adults and children, but some specific differences were noted.

The factor matrices for adults and children revealed consistent evidence that tracklength measures were highly related to number of refixations on the same task and that information search score and number of unscored frames were highly negatively related to each other, also within tasks. There was, then, strong evidence of task specificity, or as Lacey (1967) prefers to say, situational stereotypy. The intention behind Lacey's term is particularly relevant to factor loadings in the eye-movement study. Lacey objects to the term stimulus specificity on the grounds that the "term implies that the source of the response pattern lies with the

objective nature of the stimulus rather than with the nature of the subject's set and expectation, of his intended response to the stimulus" (Lacey, 1967, p. 25). It is Lacey's view that the term situational stereotypy better accomodates the relationship between objective stimulus conditions and intrapersonal set or state variables. Particular eye-movement factors for both adults and children revealed some associations among response measures taken from different tasks in which either the stimuli or the task conditions were objectively different. The loading of measures from these different tasks on one factor in some instances appears to support the notion of situational stereotypy about which Lacey writes.

For one factor in both groups, factor loadings revealed a pattern of dissociation among the variables which was interpreted as possible evidence of an habituation-like effect upon eye-movememt responses. This effect was noted for both the tracklength and refixation pair of measures, and also for the information search score and unscored frames pair.

Correlations between factors were stronger within the eye-movement study than in any of the other studies. Obliquity was especially evident within the children's matrix and could, perhaps, be interpreted as evidence of less dissociation among eye-movement psycho-motor responses in younger as compared with older subjects.

In the combined analysis of sixteen variables selected from the three response classes, six factors were extracted for adults and six for children. Differences between the pattern matrices for the

two groups were such as to suggest that the adults and children were drawn from relatively distinct populations.

The strongest inter-class dissociation among measures in the three response classes was evident with the eye-movement measures. For both adults and children there were two eye-movement factors which had no loadings of galvanic skin response or pupillary response measures. Nevertheless, in both groups at least one of the eye-movement factors had a correlation in the order of 0.20 with a factor comprising physiological measures.

The pattern of loadings within any one response class which had been observed in the three preliminary studies was generally preserved in the analysis of the combined measures. At the same time, however, three of the six factors for each group had factor loadings derived from two or more of the response classes. That is, there was distinct though limited evidence of relationships between galvanic skin response, pupillary response and eye-movement measures.

Factor scores for adults and children were interpreted as lending little or no support for the construct of a generalized orientation reaction as commonly described by some Soviet and western writers. Particularly, equivalent measures of the galvanic skin response and pupillary response failed to load on the same factor and there was evidence of neither one general orientation factor, nor of three oblique or orthogonal factors which separately might represent phasic, tonic and habituation phases of the reaction.

Instead, the analyses provided evidence of distinctly complex

relationships among the three response domains with some different patterns of dissociation evident between the two age groups. The analyses of the combined measures were interpreted as consistent with the views of Berlyne (1967), Lacey (1967) and others who propose that the relationship between physiological and psycho-motor responses might best be conceived in terms of a multidimensional rather than a unidimensional model. The multidimensional model contradicts the notion of function generality applied to the orientation construct just as it does the commonly proposed western views of a highly integrated, unidimensional arousal system. It may be noted that Ax (1967, p. 38), while concurring with Lacey's proposals on the multidimensionality of arousal, still contrasts this multidimensionality with a supposedly "fairly uniform" orienting response.

Integration

In comparison with the explicit and implicit views of many writers that orienting responses comprise a fairly uniform system or reaction, the combined evidence of the four studies which have been reported stands in rather sharp contrast. Taken together, these studies imply that the construct of the orientation reaction, as it is normally described, represents a gross oversimplification of the relationships among components and phases of the reaction. As an alternative to predominant views on the structure and functioning of the orientation reaction it is proposed that the findings of the current series of studies appear to parallel Lacey's conceptualization of the arousal system.

In relation to the construct of activation or arousal, Lacey (1967) has presented evidence and argued cogently that the commonly favored monolithic conceptualization of activation does not do justice to our observations of behavior. Lacey proposes that arousal should be a dimensionalized construct if it is to accomodate the dissociation which has been repeatedly observed both between and within various somatic and behavioral indices of arousal. He argues further that much of the observed dissociation among responses is a function of situational stereotypy. The evidence of the series of studies which have been reported appears to be broadly consistent with Lacey's position though the application is to orienting responses specifically, rather than to the more general arousal construct.

At least with respect to the galvanic skin response and pupillary dilation responses, the current analyses are held to have been concerned with orienting responses. Experimental conditions which were maintained in the gathering of observations were generally consistent with those usually described where the orientation reaction has been investigated. Furthermore, predicted responses were consistently given to the experimental stimuli and could be habituated under the regular conditions which apply to habituation.

Findings that did not appear to be consistent with popular notions of orientation behavior were the facts that: (a) differential response increments, particularly for the pupillary response, were observed under different stimulus and instructional conditions, and (b) simultaneously measured and comparable response measures for the

galvanic skin response and pupillary response were not systematically associated where the measures were collectively factor analysed. A further problem for the notion of a uniform orientation reaction was the finding of some clear differences in the pattern of response relationship observed between adults and children.

It is not as certain just what, if any, is the relationship between eye movements as measured in the reported experiment and orientation behavior. More research will be required to investigate such a possible relationship, though at least some of the response measures made are consistent with measures employed by Mackworth and Otto (1970) in their examination of what they called visual orienting responses. The analysis of combined measures selected from the three response classes revealed considerable, though not complete, dissociation between eye movements on one hand, and the remaining physiological measures on the other. It would have been helpful to have gathered eye-movement responses concurrently with the galvanic skin responses and pupillary responses but unfortunately this was not practicable in the experiment reported. Perhaps further light will be cast on the association between orienting behavior and eye movements when this is done.

Intercorrelations between eye-movement and physiological measures for the children provided a basis for some interesting speculations. Indeed, it seems possible that the use of such measures as were employed in the combined analysis might eventually permit some unravelling of functional relationships between what

might be called intensive and selective aspects of attention. For the children, two factors in the combined analysis were tentatively interpreted as representing bipolar dimensions of distractability-attentiveness. It appeared, in terms of these two factors, that those children who gave the larger orienting responses as represented by the magnitude of galvanic skin response and pupillary amplitude measures, also habituated at a slower rate than other children and tended to look away from a presented visual stimulus more frequently. Speculating, perhaps a little wildly, it appeared that these children's "attentional" behaviors might be relatively dominated by external stimuli to the detriment of goal oriented directionality or continuity in selective attention.

Concluding Discussion

Limitations of the Study

Some of the limitations in the study have already been indicated in the course of the several chapters. Among these was the treatment (by subjective estimation) of physiological artifacts which appeared to be a minor problem with the pupillary response measures. It cannot be certain how much the subjective estimations might have interfered with correlation values.

Another limitation is the somewhat arguable basis for selecting measures which were submitted to the combined analysis. While the rationale which was advanced concerning the selection of variables could be held to have some merits, it constitutes only one of several

bases for selection. A different basis which seems worth implementing sometime would be to select variables as a function of task conditions rather than factor loadings. Since there has been evidence of task specificity within the current series of studies, as there has in other investigations, a selection of variables in terms of task might reveal rather stronger association among the response measures than was demonstrated in the combined analysis. It should be recalled in passing that such dissociation was much less evident among the skin response measures than it was with either the pupillary or eye-movement measures. Both objectively and in terms of subjective observation, it may be noted also that the pupillary response appeared especially labile.

The decision to make independent analyses of responses made by subjects of two <u>different</u> age groups might also be criticized. It could be argued that two sets of subjects drawn from the same population might have been more usefully employed since this would have permitted a genuine replication study and provided for more confidence in the findings. Problems of availability of subjects, costs of transportation of school children, and the experimenter's own interest in possible developmental comparisons contributed to the choice of samples used.

The operation adopted in making eye-movement measures might constitute another limitation of the study, especially where orienting responses are the subject of scrutiny. The rationale for the selection of eye-movement measures employed has already been given and will not

be repeated here. Admittedly as a function of hindsight, the experimenter now speculates that it might be more appropriate to make the measurement of eye movements more operationally consonant with the measurement, say, of the galvanic skin response. This would mean that any change in the pattern of ongoing eye movements might come closer to reflecting visual orienting responses than those measures used in the study.

Implications

The fundamental implication of the series of studies reported is for the construct of the orientation reaction. The data have been interpreted as evidence that the construct needs elaboration to accomodate more dissociation among component responses. The functioning of the galvanic skin response appeared to fit the usual model of orientation behavior reasonably closely, but the same was not true for pupillary and eye-movement responses. Equally importantly, when different component responses are observed jointly, it appears that recognition of response dissociation becomes even more compelling.

The position arrived at in this report also casts some light upon the sometimes anomolous results of studies of orienting responses. The seemingly inconsistent findings which had been reported concerning the heart rate component of the orientation reaction have been clarified since Graham and Clifton (1966) and others began to pinpoint the directional fractionation which is characteristic of heart rate response under varying conditions of stimulus input. Some generalization of the fundamental point of the

Graham and Clifton findings, that is, evidence for response dissociation, is advanced by the findings reported herein. The seeming anomolies of some studies become less perplexing when we consider that some dissociation and situational stereotypy might be the norm.

If multidimensionality as opposed to unidimensionality of orienting behavior is accepted as a valid conceptualization, then generalizations concerning the orientation reaction must be strictly governed. Drawing on the evidence of the reported studies, generalizations concerning different stimulus conditions, response domains, and age differences appear to be especially unwise.

The educational implications of the results are neither direct nor immediately practical. They are nonetheless suggestive and important. Although the orientation reaction is commonly regarded as basically a native response mechanism, and both phylogenetic and ontogenetic evidence supports this view, it appears equally likely that modification and adaptation of the reaction is achieved through regular learning processes. If such learning is the case, then almost certainly the school is unwittingly conditioning orienting responses to particular stimulus classes and maybe even contributing to dissociation between, say, autonomic and behavioral response classes.

As an everyday example one might consider the behavior of the kindergarten or grade one child whose attentional behaviors and manifestations of arousal appear subjectively to be much more generalized and wholistic than is the case for older children. The lively motor energy and distractability of the younger children is regarded

by some as a nuisance warranting disciplinary action. By others it is regarded as a "natural" condition of age and no attempt is made to modify the behavior. Neither response to the distractability and behavioral activity of the younger child quite meets the point. A more appropriate response might be to regard the behavior as in some degree open to the influence of learning, much as reading behavior is. Specifically, the teacher would need to permit opportunities for habituation to novel stimulus events, extinguish some behavioral responses and reinforce other orienting and arousal responses. This is supposing, of course, that sitting quietly in seats for comparatively long stretches of time is educationally or in some other way desirable.

Still considering age in relation to the orientation reaction, there was some rather indeterminate evidence in the study that orienting responses might be less dissociated or dimensionalized in children than in adults. Quite consistently, and despite the greater common variance contribution of variables to the factor matrices for children, complexity among factor loadings was a characteristic of the factor solutions for children. This observation might point to a greater unity among orienting responses for children than is the case for adults. Complexity among factor loadings is normally to be avoided, at least if succinct interpretation is to be attained. But to use Cattell's (1966) phrase, "structural indications in the data itself" might be indicative of greater generality in orientation reactions for children than is true for adults.

The extraction from the analysis of combined measures of factors which seemed to be indicative of distractability-attentiveness suggests another somewhat remote implication for teaching. The author is reminded of a comment by Kagan and Lewis (1965, p. 125): "The data suggest that at 13 months the simpler repetitive point pattern is preferred to the less predictable helix. We are now studying the complex relations among complexity, novelty, and developmental stages." More is known about complexity and novelty than was so in 1965, but precious little advance has been made in exploring the effects of such stimulus characteristics upon attentional and interest behaviors with respect to curriculum materials and teaching practice.

Suggestions for Further Research

Possibilities for further research are considerable, so an exhaustive account will not be entertained here. One of the most obvious tasks to tackle, though one which is undertaken too seldom, is replication. There should be wider confirmation of dissociation among orienting responses, whether between or within specific response domains, before substantial confidence can be placed in the findings of this study.

Extensions to other developmental levels could also be fruitful. Whether such studies are cross-sectional or longitudenal in design hardly matters at this stage, though particular interest would attach to the more costly and difficult longitudenal investigations.

The current study might well have led to some misleading conclusions by averaging response measures over, in most cases, four or five trials. This was done particularly in the interests of reliability, but the literature provides some evidence for supposing that the first one or two orienting responses given to a specific stimulus might differ a little in character from those which come later. Such an investigation, of course, might be made with the data gathered in this research.

There should, too, be extensive investigation of potential person-stimulus interactions. Such studies should inquire into not only instructional and task sets as was done in the investigation reported, but could be directed to particular sub-populations such as the gifted and mentally retarded.

REFERENCES

REFERENCES

Anokhin, P. K. The role of the orienting-exploratory reaction in the formation of the conditioned reflex. In L. G. Voronin, A.N. Leontiev, A.R. Luria, E.N. Sokolov, & O.S. Vinogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. Pp. 3-16.

Ax, A. F. Invited commentary. Reply to J. U. Lacey. In M. H. Appley & S. R. Trumbull (Eds.), Psychological Stress. New York: Appleton-Century-Crofts, 1967. Pp. 37-39.

Ax, A. F. The physiological differentiation between fear and anger in humans. Psychosomatic Medicine, 1953, 15, 433-442.

Berlyne, D. E. The influence of complexity and novelty in visual figures on orienting responses. Journal of Experimental Psychology, 1958, 55, 289-296. (a)

Berlyne, D. E. Supplementary report: Complexity and orienting responses with longer exposures. Journal of Experimental Psychology, 1958, 56, 183. (b)

Berlyne, D. E. Conflict, arousal and curiosity. New York: McGraw-Hill, 1960.

Berlyne, D. E. Motivational problems raised by exploratory and epistemic behavior. In S. Koch (Ed.), Psychology: A study of a science. Vol. 5. New York: McGraw-Hill, 1963. Pp. 284-364.

Berlyne, D. E. Conflict and the orientation reaction. Journal of Experimental Psychology, 1961, 62, 476-483.

Berlyne, D. E. Emotional aspects of learning. Annual Review of Psychology, 1964, 15, 115-142.

Berlyne, D. E. Arousal and reinforcement. In D. Levine (Ed.), Nebraska symposium on motivation. Lincoln: University of Nebraska Press, 1967. Pp. 1-110.

Berlyne, D. E. Attention as a problem in behavior theory. In D. Mostofsky (Ed.), Attention: Contemporary theory and analysis. New York: Appleton-Century-Crofts, 1970. Pp. 25-49.

Berlyne, D. E., Craw, M. A., Salapatek, P. H., & Lewis, J. L. Novelty, complexity, incongruity, extrinsic motivation, and the GSR. Journal of Experimental Psychology, 1963, 66(6), 560-567.

Bernstein, A. S. To what does the orienting response respond? Psychophysiology, 1969, 6(3), 338-350.

Biriukov, D. A. On the nature of the orienting reaction. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. Pp. 17-24.

Boersma, F. J., Muir, W., Wilton, K., & Barham, R. Eye movements during embedded figure tasks. Perceptual and Motor Skills, 1969, 28, 271-274. (a)

Boersma, F. J., Muir, W., Wilton, K., & Barham, R. Eye movements during anagram tasks. Perceptual and Motor Skills, 1969, 29, 371-374. (b)

Boersma, F.J., Wilton, K., Barham, R., & Muir, W. Effects of arithmetic problem difficulty on pupillary dilation in normals and educable retardates. Journal of Experimental Child Psychology, 1970, 9, 142-155.

Bradshaw, J. L. Load and pupillary changes in continuous processing tasks. British Journal of Psychology, 1968, 59(3), 265-271.

Bronstein, A. I., Itina, N. A., Kamenetskaia, A.G. & Sytova, V. A. The orienting reactions in newborn children. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Viogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. P. 307-313.

Campos, J. J., & Johnson, H. J. The effects of verbalization instructions and visual attention on heart rate and skin conductance. Psychophysiology, 1966, 2(4), 305-310.

Cattell, R. B. The meaning and strategic use of factor analysis. In R. B. Cattell (Ed.), Handbook of multivariate experimental psychology. Chicago: Rand McNally and Company, 1966. Pp. 174-243.

Conklin, R. C., Muir, W., & Boersma, F. J. Field dependency-independency and eye-movement patterns. Perceptual and Motor Skills, 1968, 26, 59-65.

Cronbach, L. J., & Meehl, P. E. Construct validity in psychological tests. Psychological Bulletin, 1955, 52, 281-302.

Darrow, C. W. The rationale for treating the change in galvanic skin response as a change in conductance. Psychophysiology, 1964, 1(1), 31-38.

Darrow, C. W. Problems in the use of the galvanic skin response (GSR) as an index of cerebral function: Implications of the latent period. Psychophysiology, 1967, 3(4), 389-396.

Edelberg, R., & Burch, N. R. Skin resistance and galvanic skin response. Archives of General Psychiatry, 1962, 7, 163-169.

Eysenck, H. J. Criterion analysis--An application of the hypothetico-deductive method of factor analysis. Psychological Review, 1950, 57, 38-53.

Galbrecht, C. R., Dykman, R. A., Reese, W. G., & Suzuki, T. Intrasession adaptation and intersession extinction of the components of the orienting response. Journal of Experimental Psychology, 1965, 70(6), 585-589.

Graham, F. K., & Clifton, R. K. Heart-rate change as a component of the orienting response. Psychological Bulletin, 1966, 65, 305-320.

Graschenkov, N. I., & Latash, L. P. O role orientirovochnoi reaskii v organizatsii deistviya. Voprosy Psikhologii, 1965, 1, 21-41. (Psychological Abstracts, 1965, 39, No. 9534)

Guilford, J. P. Factor analysis in a test-development program. Psychological Review, 1948, 55, 79-94.

Haggard, E. A. On the application of analysis of variance to GSR data: I The selection of an appropriate measure. Journal of Experimental Psychology, 1949, 39, 378-392.

Hakstian, A. R. A computer program for oblique factor transformation using the generalized Harris-Kaiser procedure. Educational and Psychological Measurement, 1970, 30, 703-705.

Haliburton, T. C. Sam Slick in pictures: The best of the humor of Thomas Chandler Haliburton. Illustrated by C. W. Jeffery, L. Pierce (Ed.), Toronto: Ryerson Press, 1956.

Harris, C.W., & Kaiser, H. F. Oblique factor analytic solutions by orthogonal transformations. Psychometrika, 1964, 29, 347-362.

Houck, R. L., & Mefferd, R. B. Generalization of GSR habituation to mild intrmodal stimuli. Psychophysiology, 1969, 6(2), 202-206.

Israel, Nancy R. Individual differences in GSR orienting response and cognitive control. Journal of Experimental Research in Personality, 1966, 1(4), 244-248.

Kagan, J., & Lewis, M. Studies of attention in the human infant. Merrill Palmer Quarterly, 1965, 11, 95-127.

Kahneman, D., & Beatty, J. Pupil diameter and load on memory. Science, 1966, 154, 1583-1585.

Kahneman, D., Beatty, J., & Pollack, I. Perceptual deficit during a mental task. Science, 1967, 157, 218-219.

Kimmel, H. D., Pendergrass, V. E., & Kimmel, E. B. Modifying children's orienting reactions instrumentally. Conditioned Reflex, 1967, 2, 227-235.

Korn, J. H., & Moyer, K. E. Effects of set and sex on the electrodermal orienting response. Psychophysiology, 1968, 4(4), 453-459.

Kreindler, A., Krigel', E., & Poilich, I. Electroentsefalograficheskie i vegetativnye izmeneniia pri poilavlenii i ugashenii orientirovachnoi reactsiei na bezuslovnye rechevye stimuly u liudei v norme i pri afazii. Zhurnal Vysshei Nervnoi Deiatel'nosti, 1963, 13(1), 11-18. (Psychological Abstracts, 1964, 38, No. 5372)

Krugman, H. E. Processes underlying exposure to advertising. American Psychologist, 1968, 23(4), 245-253.

Lacey, J. I. Somatic response patterning and stress: Some revisions of activation theory. In M. H. Appley & S. R. Trumbull (Eds.), Psychological stress. New York: Appleton-Century-Crofts, 1967. Pp. 14-42.

Lacey, J. I., & Lacey, B.C. Verification and extension of the principle of autonomic response-stereotypy. American Journal of Psychology, 1958, 71, 50-73.

Lebedinskaia, E. I., Feigenberg, I. M., & Freierov, O. E. Generalized orientation responses in the defective state of schizophrenia. Soviet Psychology and Psychiatry, 1962, 1(1), 51-57.

Lewis, M., & Goldberg, S. The acquisition and violation of expectancy: An experimental paradigm. Journal of Experimental Child Psychology, 1969, 7, 70-80.

Luria, A. R. The mentally retarded child. Oxford: Pergamon Press, 1963.

Luria, A. R., & Vinogradova, O. S. Peculiarities of the orientations reflexes in child-ologophrenics. In A. R. Luria (Ed.), The mentally retarded child. Oxford: Pergamon Press, 1963. Pp. 97-108.

Lykken, D. T. Properties of electrodes used in electrodermal recording. Journal of Comparative and Physiological Psychology, 1959, 52(6), 629-634.

Lynn, R. Attention, arousal and the orientation reaction. Oxford: Pergamon Press, 1966.

Mackworth, N. H. A stand camera for line-of-sight recording. Perception and Psychophysics, 1967, 2, 119-127.

Mackworth, N. H., & Bruner, J. S. Measuring how adults and children search and recognize pictures. Human Development, 1970, 13, 149-177.

Mackworth, N. H., Kaplan, I. T., & Metlay, W. Eye movements during vigilance. Perceptual and Motor Skills, 1964, 18, 397-402.

Mackworth, N. H., & Otto, D. Habituation of the visual orienting response in young children. Perception and Psychophysics, 1970, 7(3), 173-178.

Martin, I. The measurement of skin resistance. Bulletin of British Psychological Society, 1964, 17, 13-16.

Maltzman, I., & Raskin, D. C. Effects of individual differences in the orienting reflex on conditioning and complex processes. Journal of Experimental Research in Personality, 1965, 1, 1-16.

Montagu, J. D., & Coles, E. M. Mechanism and measurement of the galvanic skin response. Psychological Bulletin, 1966, 65, 261-277.

Mostofsky, D. I. Attention: Contemporary theory and analysis. New York: Appleton-Century-Crofts, 1970.

Nikitina, G. M., & Novikova, E. G. On the characteristics of the manifestation of the orienting reaction in animals during ontogenesis. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. Pp. 314-322.

Pavlov, I. P. Conditioned reflexes. Oxford: Clarendon Press, 1927.

Polikanina, R. I., & Probatova, L. E. On the problem of formation on the orienting reflex in prematurely born children. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. Pp. 330-340.

Raskin, D. C., Hattle, M., Harris, L., & DeYoung, G. The effects of stimulus intensity, duration, and inter-stimulus interval on evocation and habituation of orienting and defensive reflexes. Psychophysiology, 1968, 4(4), 504-505.

Razran, G. The observable unconscious and the inferable conscious in current Soviet psychophysiology: Interoceptive conditioning, semantic conditioning, and the orienting reflex. Psychological Review, 1961, 68, 81-147.

Reese, H. W., & Lipsitt, L. P. Experimental child psychology. New York: Academic Press, 1970.

Rozhdestvenskaia, V. I., Nebylitsyn, V. D., Borisova, M. N., & Ermolaeva-Tomina, L. B. A comparative study of various indicators of the strength of the human nervous system. Soviet Psychology and Psychiatry, 1963, 1, 10-23.

Sokolov, E. N. Neuronal models and the orienting reflex. In M. A. Brazier (Ed.), The central nervous system and behaviour. New York: J. Macy, 1960.

Sokolov, E. N. Perception and the conditioned reflex. Oxford: Pergamon Press, 1963.

Sokolov, E. N. The orienting reflex, its structure and mechanisms. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. Pp. 141-151.

Sokolov, E. N. Orienting reflex as information regulator. In A. Leontiev, A. Luria, & A. Smirnov (Eds.), Psychological research in the U.S.S.R.. Vol. 1. Moscow: Progress Publishers, 1966. Pp. 334-360.

Stern, J. A. Toward a developmental psychophysiology: My look into the crystal ball. Psychophysiology, 1968, 4(4), 403-420.

Sternbach, R. A., Alexander, A. A., Rice, D. G., & Greenfield, N. S. Technical note: Some views on the treatment of "artifacts" in psychophysiological recordings. Psychophysiology, 1969, 6(1), 1-5.

Surwillo, W. W. The influence of some psychological factors on latency of the galvanic skin reflex. Psychophysiology, 1967, 4(2), 223-228.

Taylor, S. P., & Epstein, S. The measurement of autonomic arousal. Psychosomatic Medicine, 1967, 29, 514-525.

Teplov, B. M., & Nebylitsin, V. D. Results of experimental studies on properties of the nervous system in man. In A. Leontiev, A. Luria, & A. Smirnov (Eds.), Psychological research in the U.S.S.R.. Vol. 1. Moscow: Progress Publishers, 1966. Pp. 181-198.

Torbit, G. Visual search behavior of children. Unpublished masters thesis, University of Alberta, 1970.

Uno, T., & Grings, W. W. Autonomic components of orienting behavior. Psychophysiology, 1965, 1, 311-321.

Volochov, A. A. Uber die rolle der hoheren Anteile des Gehirns bei der Korrelation der vegetativenx und somatischen Komponenten bedingter Reaktionen in der Ontogenes, Abhandlungen der deutschen Akademie der Wissenschaften zu Berlin, 1966, 2, 413-414. (Psychological Abstracts, 1967, 41, No. 7084)

Voronin, L. G., Leontiev, A. N., Luria, A. R., Sokolov, E. N., & Vinogradova, O. S. Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965.

Wechsler, D. The measurement and appraisal of adult intelligence. Baltimore: The Williams and Wilkins Co., 1959.

Wolfensberger, W., & O'Connor, N. Relative effectiveness of galvanic skin response latency, amplitude and duration scores as measures of arousal and habituation in normal and retarded adults. Psychophysiology, 1967, 3(4), 345-350.

Woodmansee, J. J. Methodological problems in pupillographic experiments. Proceedings of the 74th annual convention of the APA, 1966, 133-134.

Zaporozhets, A. V. O deistvennon kharaktere zritel'nogo vospriiatiia predmeta, Dokl. Akad. Pedag. Nauk RSFSR, 1962, 1, 77-80. (Psychological Abstracts, 1963, 37, No. 2328)

Zaporozhets, A. V. The role of the orienting activity and of the image in the formation and performance of voluntary movements. In L. G. Voronin, A. N. Leontiev, A. R. Luria, E. N. Sokolov, & O. S. Vinogradova (Eds.), Orienting reflex and exploratory behavior. Washington: American Institute of Biological Sciences, 1965. Pp. 434-440.

Zimny, G. H., Pawlick, G. F., & Saur, D. P. Effects of stimulus order and novelty on orienting responses. Psychophysiology, 1969, 6(2), 166-173.

Zimny, G. H., & Schwabe, L. W. Stimulus change and habituation of the orienting response. Psychophysiology, 1965, 2(2), 103-115.

Zinchenko, V. P., & Lomov, B. F. The functions of hand and eye movements in the process of perception. Problems of Psychology, 1960, Nos. 1 & 2, 12-25.

APPENDIX A

Task Instructions Given to Subjects

TASK INSTRUCTIONS GIVEN TO SUBJECTS

Task Instructions to Adults

Preliminary Instructions

"First, may I thank you for your willingness to take part in this study. We are grateful for your participation. You will understand, of course, that we cannot explain the purpose of the study at this stage. Briefly, though, we are simply interested in the behavior of the eye and the galvanic skin response in relation to a variety of stimuli. Most of the tasks are very simple, and you are asked merely to remain in your chair and to follow instructions as they are given. In just a moment, we shall ask you to lean forward into the head-rest, and to bite on a bite bar. The purpose of this bar, made of dental compound, is to enable you to keep your head steady while recordings on the behavior of your eye are being taken. Would you lean forward now, please, bite into the bar gently, and then come off again."

Non-signal (tone stimulus), Non-signal Habituation (tone stimulus) and Non-signal Dishabituation (tone stimulus)

"For the next seven or eight minutes, your only task is to keep your eyes looking within the black circle in front of you. Recordings will be taken during this time and we shall tell you as soon as this part of our work is finished. Just relax, and keep your teeth on the bite bar, and look only within the black

circle. Try to avoid frequent blinking, but if you feel the need for much blinking, close your eyes firmly for a moment and quickly resume looking at the white square with the black circle. Your only task, remember, is to look within the black circle in front of you."

Auditory Anagrams

"Now we are going to try some anagrams. These are scrambled letters which may be rearranged to make a word. Here's an example: u - f - n may be rearranged to make f - u - n, fun. Here's another: the letters t - a - s - f may be rearranged to make f - a - s - t, fast. I shall say over the letters once, slowly, and you are to make a word out of them. Keep your eyes looking within the black circle, please, while you are solving the problem, and try to avoid blinking. Got it? Look within the black circle while you are solving the anagrams, and shut your eyes as soon as you have the answer."

Visual Anagrams

"This time, let's try some visual anagrams. These are scrambled letters which may be rearranged to make a word. Here's an example: u - f - n may be rearranged to make f - u - n, fun. Here's another: the letters t - a - s - f may be rearranged to make f - a - s - t, fast. The letters will appear on the white screen in front of you and you are to make a word out of them. As soon as you have solved the problem, please shut your eyes. Try to avoid

blinking while you are solving the problem. Please remember to shut your eyes as soon as you have the answer."

Signal (tone stimulus)

During the instructions for this task each subject was shown a button mounted on a piece of wood and instructed to press it several times.

"Well, we're half-way through now and this will be the last task in which we have that red light shining in your eye. We're going well, so let's see what we can do with this one. We shall have some more of those little "beep" sounds which we had at the beginning, but every time you hear a "beep," I want you to think of pressing this button. Feel it now, and press the button. Try again; press it a few times. Good. Now we shall take the button away. Please lie your right hand flat on the table. Remember, your only task is to imagine, or think of pressing the button whenever you hear the "beep," but don't actually move your hand or fingers in any way. Ready then? Keep your eyes looking in the black circle all the time. We'll get going."

Non-directed Search (Sam Slick pictures), Prolonged Search (Sam Slick pictures) and Non-directed Search (line drawings)

"In this next part of our session, a series of pictures will be shown on the white square, but there will be no problem to solve on your part. Once again, your only task will be to keep your eyes on the illuminated square. You may look at the pictures,

of course, but you will not be asked to respond to them in any way. Between each new picture, the grid which you have just been looking at will be shown. Please look from the center to each of the four corners, as you did a moment ago. Remember, your only task is to keep your eyes on the picture in the illuminated square. Right? Let's go."

Directed Search (WAIS incomplete pictures)

"In the next three pictures, your task is to find which important part of the drawing is missing. In each picture, there will be something missing, and you are to close your eyes as soon as you have discovered the missing part. I shall then ask you for your answer. Ready now? We shall have another look at the grid before we get going. Remember, you are to discover what important part is missing from the picture. Close your eyes as soon as you've done so."

Directed Search (Sam Slick pictures)

"Now we shall have some more pictures, but this time, after each has been shown for a few seconds, you will be asked to recall as many elements or objects from the picture as possible. Just try to remember as much as you can. We shall begin now."

Task Instructions to Children

Non-signal (tone stimulus), Non-signal Habituation (tone stimulus) and Non-signal Dishabituation (tone stimulus)

"Now listen carefully and I'll tell you what we are going to do. Ready now. Just look straight ahead and keep looking inside the black circle. I want you to sit just as still as you can for seven minutes; I shall tell you as soon as you can stop. Have you got that? Sit as still as can be, and keep your eyes looking inside the black circle. Don't let your eyes look outside the circle at all. Right. We'll start now."

Auditory Anagrams

Prior to the instructions, each subject was given two or three examples to demonstrate the task.

"Now we are going to play that word game again, but I want you to sit very still this time while we play it. I am going to tell you the mixed-up letters over these earphones, and you must listen very carefully to hear them. Then see if you can make a word you know out of them. Close your eyes as soon as you have the word. Did you understand the game? Let me tell you again. Sit very still. Listen carefully for the mixed-up letters. Try to make a word you know out of them. Then close your eyes as soon as you have the word. Right. Let's try it."

Visual Anagrams

Prior to the instructions, each subject was given two or three examples to demonstrate the task.

"Now we are going to play that word game again, but I want you to sit very still this time while we play it. I am going to put the mixed-up letters on the screen, and you see if you can make a word you know out of them. Try as hard as you can, and as soon as you have found the word, close your eyes. Got the idea? Sit very still. Look at the mixed-up letters. Make a word you know out of them, and as soon as you have got the word, close your eyes. Let's start now."

Signal (tone stimulus)

During the instructions for this task each subject was shown a button mounted on a piece of wood and instructed to press it several times.

"What I want you to do now is just to sit still, look straight ahead inside the black circle, and listen for some little "beep" sounds that will be coming over the earphones. When you hear one of these sounds, I want you to pretend you are pressing a button like this one, but I don't want you to move your hand or fingers at all. I'll tell you again. Just sit still in your chair, look straight ahead, and pretend you are pressing this button whenever you hear the "beep" sound."

Non-directed Search (Sam Slick pictures), Prolonged Search (Sam Slick pictures) and Non-directed Search (line drawings)

"This time I am going to show you some pictures which you may look at. I want you to do your very best to keep your head still while I am showing you the pictures. That's easy, isn't it? Just sit as still as can be, and I shall put some different pictures on the screen. Are you ready, now? Look straight ahead at the screen and we shall look at that big square again before we start."

Directed Search (WAIS incomplete pictures)

Prior to the instructions, each subject was given an example to demonstrate the task.

"I am going to show you some more pictures now and I want you to tell me what part is missing, just like we did a minute ago. Look carefully at the pictures, find out what is missing, and as soon as you can tell me, shut your eyes. Have you got that? As soon as you have found out what is missing in the picture, shut your eyes and I will know that you have got the answer. Let me tell you again. Look at the picture. Find out what part is missing, then close your eyes as soon as you have the answer. Good. Let's look at the big square again before we start."

Directed Search (Sam Slick pictures)

"Now we have more pictures for you to look at. I want you to look at them carefully; then I am going to ask you to tell me all that you can remember about the pictures. That's easy, isn't it? Just look at the picture carefully, and then we shall ask you to

tell us all about it. Let's look around the big square again before we start."

APPENDIX B

Anagram Problems, and Visual Stimuli

for Eye-Movement Study

ANAGRAM PROBLEMS

Problems Given to Adults

Auditory Problems

1. i--t--y--n (tiny)
2. r--c--d--a (card)
3. n--p--e--l (pine)
4. a--f--e--m (fame)

Visual Problems

	e	d	
1.			(drew)
	r	w	
	u	h	
2.			(huge)
	e	g	
	i	s	
3.			(sigh)
	g	h	
	s	p	
4.			(push)
	h	u	

Problems Given to Children

Auditory Problems

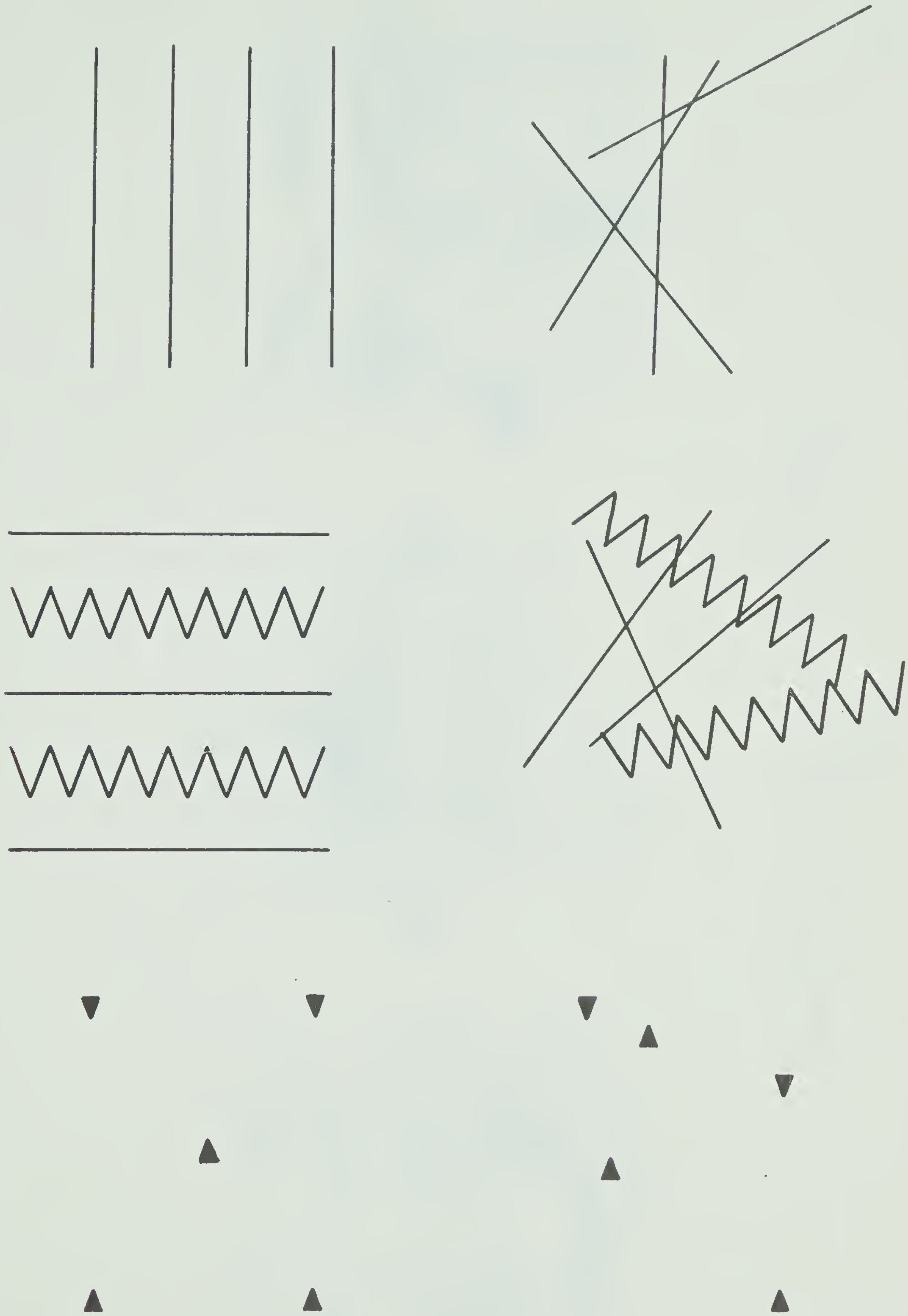
1. a--y--w (way)
2. o--c--w (cow)
3. e--g--b (beg)
4. t--l--e (let)

Visual Problems

		e		
1.	n		m	(men)
		p		
2.	u		t	(put)
		b		
3.	r		a	(bar)
		e		
4.	n		p	(pen)

Sam Slick Pictures Used in Non-Directed and Prolonged Search--Tasks 1 and 2

Figure 2



Line Drawings Used in Non-Directed Search--Task 3

Figure 3

Incomplete Pictures Used in Directed Search--Task 4

Figure 4

Sam Slick Pictures Used in Directed Search--Task 5

Figure 5

APPENDIX C

Instructions for Judges' Information Search Score Ratings

INSTRUCTIONS FOR JUDGES' INFORMATION SEARCH SCORE RATINGS

Instructions for Rating Stimulus Pictures in Tasks 1, 2 and 5

Each cell in this picture is to receive a score from 0 (lowest) to 5 (highest) depending upon the amount of information you feel the cell contributes to the picture as a whole, relative to the other cells in the picture.

An approach to rating the cells which you may find helpful is:
(a) Locate what you think is the highest information content area(s) in the picture and assign this cell(s) the appropriate weighting.
(b) Locate the cell(s) which you think contribute little or no information to the picture as a whole, and assign this cell(s) the appropriate weighting.
(c) Rate the remaining cells in the picture relative to their proximity to and importance for cells of high information content.

Instructions for Rating Stimulus Pictures in Task 4

The instructions for rating the Incomplete Pictures from the WAIS differed from those for the other tasks only in that the cell(s) receiving the highest rating would center around the area where the missing element was located. Further, the judges were asked to rate any obvious cue as to the nature of the missing element according to its relative importance.

APPENDIX D

Eigenvalues for All Reported Factor Matrices

Table 38

Eigenvalues for Adults--Reported by Table Number

Eigenvalue Number	Table 7	11	16	20	27	34
1	6.331	2.765	2.613	2.231	4.417	2.769
2	2.874	2.113	2.290	1.931	2.668	2.248
3	2.175	1.049	1.784	1.340	2.164	1.878
4	1.445	0.892	1.418	1.146	1.815	1.490
5	1.133	0.842	1.204	0.746	1.320	1.348
6	0.990	0.691	1.103	0.692	1.241	1.175
7	0.841	0.346	1.073	0.537	1.059	1.033
8	0.761	0.298	0.656	0.377	0.897	0.948
9	0.651	0.003	0.545	-0.000	0.750	0.760
10	0.467		0.474		0.560	0.634
11	0.415		0.375		0.410	0.465
12	0.299		0.237		0.404	0.401
13	0.186		0.226		0.373	0.282
14	0.166		-0.000		0.297	0.251
15	0.100				0.245	0.206
16	0.092				0.170	0.112
17	0.057				0.110	
18	0.015				0.051	
19	0.002				0.049	

Table 39

Eigenvalues for Children--Reported by Table Number

Eigenvalue Number	Table 8	12	17	21	28	35
1	5.083	3.772	3.233	2.626	4.409	2.996
2	3.954	2.091	2.664	2.415	2.708	2.475
3	1.928	1.297	1.717	1.246	2.470	1.752
4	1.649	0.637	1.336	1.039	1.903	1.715
5	1.231	0.500	1.094	0.707	1.505	1.510
6	1.185	0.421	0.993	0.377	1.205	1.224
7	1.085	0.204	0.671	0.330	1.020	0.979
8	0.861	0.064	0.624	0.260	0.941	0.819
9	0.723	0.014	0.598	-0.000	0.662	0.624
10	0.496		0.526		0.583	0.492
11	0.352		0.338		0.365	0.383
12	0.305		0.210		0.314	0.338
13	0.173		0.076		0.260	0.254
14	0.142		-0.000		0.216	0.203
15	0.116				0.136	0.161
16	0.079				0.118	0.074
17	0.022				0.091	
18	-0.080				0.057	
19	-0.304				0.036	